ITROUS OXIDE & OXYGEN

FOR DENTAL OPERATIONS

Frederic W. Hewitt,
M.D.

THE
ADMINISTRATION OF NITROUS OXIDE
AND
OXYGEN FOR DENTAL OPERATIONS.

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THE ADMINISTRATION OF

Nitrous Oxide and Oxygen

FOR

DENTAL OPERATIONS

BY

FREDERIC W. HEWITT, M.V.O., M.A., M.D. CANTAB.

Anæsthetist to His Majesty the King; late Anæsthetist to His Majesty King Edward VII.; Physician-Anæsthetist to St. George's Hospital; Consulting Anæsthetist and Emeritus Lecturer on Anæsthetics at the London Hospital; late Anæsthetist at the London Hospital, Charing Cross Hospital, and the Royal Dental Hospital of London

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TO

THOSE

SURGEONS AND ASSISTANT SURGEONS

OF THE

ROYAL DENTAL HOSPITAL OF LONDON

WITH WHOM I WAS ASSOCIATED WHILST MAKING

MOST OF THE OBSERVATIONS HEREIN CONTAINED,

I VENTURE TO

DEDICATE

THIS LITTLE BOOK,

IN GRATEFUL RECOGNITION OF THEIR COURTESY

AND KIND ASSISTANCE.

PREFACE TO THE FOURTH EDITION.

In spite of the fact that a considerable number of developments have taken place in practical anæsthetics since the appearance of the third edition of this book, there can be no doubt, I think, that the form of anæsthesia herein advocated still holds its own as the safest and best for the ordinary or routine operations of dental surgery.

It is gratifying to find that the main thesis originally put forward in these pages is now universally accepted, and that the comparatively crude method of administering nitrous oxide, which widely prevailed only a few years back, is gradually but surely losing the position it formerly occupied.

The principal, but by no means the only additions that have been made to the text of this edition, will be found in the chapter dealing with Exceptional Cases.

FREDERIC W. HEWITT.

London,
June, 1911.

PREFACE TO THE SECOND EDITION.

SINCE the appearance of the first edition of this little book, the system of administering oxygen with nitrous oxide has become firmly established in dental practice.

The only correction, worthy of the name, which it has been necessary to make in preparing the present edition, will be found in the first chapter. Thanks to a reference discovered and kindly furnished me by Messrs. Ash and Sons, it is now perfectly clear that the credit of first employing oxygen with nitrous oxide should be given to Andrews, of Chicago.

The only additional matter of any importance is to be found in Chapter II, which contains a *résumé* of the research to which reference was made in the Preface of the former edition, and also a description of a slight modification in my apparatus, by which I am enabled at any moment during an administration to suddenly increase the oxygen percentage to any desired extent, and so to successfully deal with exceptional cases.

FREDERIC W. HEWITT.

October, 1901.

PREFACE TO THE FIRST EDITION.

ELEVEN years have elapsed since I commenced working at this subject. The first eight years were mainly devoted to conducting preliminary experimental administrations of various mixtures of nitrous oxide and oxygen, and to devising and perfecting apparatus. The last three years have been occupied in ascertaining the precise influences exerted by this or that percentage of air or of oxygen upon the usual asphyxial phenomena of pure nitrous oxide.

My original intention was to incorporate in one volume the results of both parts of the research, but I have since decided to adopt a different course, and to first place in the hands of the medical and dental professions this small treatise dealing more particularly with the practical aspects of the subject, and subsequently to bring forward the large mass of evidence which I now possess concerning the physiological effects of different mixtures of nitrous oxide with air or oxygen.

Safe and thoroughly efficient anæsthesia for dental operations is of such importance that it behoves every dental practitioner to carefully consider whether he should not abandon the prevalent but comparatively crude and unscientific method of producing

insensibility from nitrous oxide and avail himself of the new system.

It is true that there are at present some difficulties in the way of this advance, but it is to be hoped that they may soon be surmounted. The principal of these undoubtedly is the difficulty of obtaining proficient anæsthetists. Increased facilities, however, are now being afforded at most hospitals for acquiring experience in administering anæsthetics, so that there is every reason to believe that in the course of time there will not be that dearth which now exists of medical men capable of administering nitrous oxide in dental practice.

Moreover, I hope to see the day when the immense amount of clinical material which is now being wasted, so to speak, at our dental hospitals, will be utilised, not only for the systematic instruction of dental students who are intending to qualify in medicine, but for that of extraneous students and practitioners. In this way it would be possible efficiently to train medical men in dental anæsthetics, and to keep the dental profession supplied, as it were, with proficient anæsthetists throughout the country.

FREDERIC W. HEWITT.

May, 1897.

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CHAPTER I.

INTRODUCTORY.

In reviewing the past history of nitrous oxide as an anæsthetic, one cannot help being struck by the singular vicissitudes which this agent has experienced. That a quarter of a century should have passed between its discovery by **Priestley,** and the recognition of its pain-relieving properties by **Davy,** is sufficiently remarkable. But more curious still is the fact that nearly double this length of time elapsed between Davy's observations and the first administration of the gas for a surgical operation. It was during this latter interval that nitrous oxide received the name of "laughing gas," from the power it possesses, when small quantities are breathed backwards and forwards, of producing hilarious excitement.

In December, 1844, Dr. **Colton,** "an

itinerant lecturer on chemistry" (to use a description given of him by one of his own countrymen) [1] demonstrated these effects at Hartford, Conn., U.S.A. At this entertainment **Horace Wells,** a dentist, was present, and noticing that one of the audience who had inhaled the gas had unconsciously bruised himself whilst under its influence, he shrewdly suspected that the so-called "laughing gas" might prove to be of valuable service in dentistry. This brilliant idea was quickly put to the test; Colton administered the gas to Wells; and a friend of the latter extracted a tooth during the anæsthesia thus produced. This administration of nitrous oxide, although conducted in the crudest manner, will ever deservedly remain a memorable one; for it laid the foundation-stone, so to speak, of our present system of surgical anæsthesia.

The realisation of the hopes which Wells had entertained was so complete that he naturally enough looked forward to an uninterrupted and glorious reign for the new anæsthetic whose services in surgery he had been the first to requisition. Unfortunately, however, a public demonstration which he gave proved a fiasco; and this circumstance, together with the fact that widespread interest was now being excited by the discovery of the anæsthetic properties of ether, rapidly placed nitrous oxide

again upon the shelf, where it remained, more or less forgotten, for a further term of nearly twenty years. A little reflection will at once show that Wells' anæsthetic was heavily handicapped in its struggle for existence. Its physical characters. were against it. Being gaseous at ordinary temperatures and pressures it was, as compared to its liquid rivals ether and chloroform, more or less unmanageable. It was, moreover, a difficult matter to obtain the gas in a state of purity and in sufficiently large quantities for administration. But the chief cause of the discredit into which nitrous oxide fell was the want of knowledge which necessarily prevailed as to the principles which should be followed in its administration. The methods employed by Wells and his followers were such as to render success or failure merely a matter of chance. The administration was very simply conducted. Some of the gas was placed in a bag or bladder to which was attached a tube, and the patient breathed the gas backwards and forwards. The results which followed were necessarily exceedingly uncertain, as the chronicled accounts of Wells' demonstration and of subsequent attempts to produce anæsthesia amply testify. In addition to the fact that much of the nitrous oxide which was employed itself contained air, it must be remembered that the re-breathing of a small

quantity of the gas necessarily led to its dilution by the air already present in the respiratory passages. The early administrations of nitrous oxide were, indeed, administrations of nitrous oxide mixed with considerable proportions of nitrogen, oxygen, and carbonic acid gas, to say nothing of the impurities other than air which may or may not have been present in the anæsthetic employed for inhalation. Loud and prolonged laughter, crying, shouting, praying, semi-maniacal excitement, and many grotesque and amusing phenomena manifested themselves—phenomena which we now know to have been produced by the too free dilution of the gas with the oxygen of atmospheric air. In some of the cases in which teeth were removed no pain was experienced; in others the pain was only mitigated; in many the pain was felt with the usual or even more than the usual acuteness.

It was not until 1863 that nitrous oxide again began to emerge from the seclusion into which it had been forced by reverses of fortune. In this year a dentist named **Smith**, of New Haven, Conn., took upon himself the responsibility of submitting one of his patients to its influence, and the results were this time so satisfactory that Colton, who was again the administrator, forthwith proceeded to New York, where, with several influential dentists,

he established an Association bearing his name for the painless extraction of teeth. Writing in March, 1881, Dr. Colton stated that no less than 121,709 administrations of nitrous oxide had been conducted by the Colton Dental Association since July 1863, when the Association was founded, and that no accident had occurred.

The news of Colton's success soon crossed the Atlantic, and in January, 1864, Mr. **Rymer,** a London dentist, reported [2] some experimental administrations of nitrous oxide which he had undertaken at the National Dental Hospital. In these experiments either a bladder or an india-rubber bag was used, and the patient breathed the gas backwards and forwards through a tube of large calibre. According to the interesting paper published by Mr. Rymer the results were very satisfactory.

So far as the author is able to ascertain, the first apparatus which possessed valves to prevent re-breathing was that used by Dr. **Evans,** of Paris, at a very successful demonstration which he gave at the Dental Hospital of London in 1868. The introduction of this improved method of administration was quickly followed by the manufacture of liquefied nitrous oxide; and for the first time since Horace Wells' experiment, nitrous oxide began to occupy an unassailable position amongst its

rivals in the great field of therapeutics. **Clover,** whose ingenuity in devising other anæsthetic apparatus had already become conspicuous, quickly improved upon the still rough nitrous-oxide inhalers, and laid down rules to be observed in administration.

The complications which had attended the earlier administrations of nitrous oxide, if such they can be called, had been due to the presence of atmospheric air in too large quantities. Those which now began to appear with the more perfected apparatus were of an exactly opposite nature. The recognition of the effects produced by the admixture of air now led to its most stringent exclusion. The pendulum, in fact, began to swing just as far in this direction as it had swung in the other. It was thought that because air produced excitement it should necessarily be wholly excluded—a view which subsequent experience has taught us to modify. With this new system of administration it soon became clear that a continuous inhalation was impossible for more than about a minute. Provided that no air whatever gained admission with the anæsthetic gas, that no re-breathing was permitted and that the inhaling apparatus fitted the face accurately and worked well, nitrous oxide could not be given for more than a very brief space of time. After the inhalation had lasted a

minute or so, certain phenomena arose which necessitated the withdrawal of the anæsthetic and the admission of air. It was therefore concluded that nitrous oxide was suitable only for very brief operations. Prolonged surgical procedures could only be accomplished under its influence, and these not very satisfactorily, by intermittently allowing air to be respired.

The next step in the development of nitrous oxide anæsthesia was taken by Professor **E. Andrews,** [3] of the Medical College, Chicago, who after making experiments upon lower animals succeeded in anæsthetising human beings by means of mixtures of nitrous oxide and oxygen. Andrews found that by the use of such mixtures he was able to render nitrous oxide continuously respirable, and to prevent the usual asphyxial accompaniments of the anæsthesia.

Little or no notice appears to have been taken of the interesting cases published by Andrews. At all events, it was not until several years later, when the French physiologist **Paul Bert** began to study the subject, that the advantages of oxygen in conjunction with nitrous oxide again attracted attention. In a communication which Bert made to the Société de Biologie on Feb. 9, 1878, he stated [4] that he found the effects of toxic gases upon living organisms to be dependent upon

their tension when breathed. Nitrous oxide was a gas which, at the ordinary atmospheric pressures, would only produce anæsthesia when administered *pure*, *i.e.*, free from air. Unfortunately, however, in administering nitrous oxide free from all air, asphyxial phenomena soon became developed. But if a mixture of one half nitrous oxide and one half air were administered in a close chamber in which the ordinary barometric pressure could be doubled, then the blood would receive just as much nitrous oxide as when the gas was administered pure at ordinary pressures, and just as much air as would be breathed under natural circumstances. In this way prolonged anæsthesia would be possible and asphyxia prevented. As we shall subsequently see, Bert's original proposition as to the necessity of employing perfectly pure nitrous oxide for the production of anæsthesia was not true. He soon found, moreover, that by using oxygen instead of air it was unnecessary to dilute the nitrous oxide to anything like the extent above indicated, so that only a comparatively small increase in barometric pressure was needed. On the 11th May, 1878, Bert stated [5] that he had successfully anæsthetised a dog with a mixture of 80 per cent. of nitrous oxide and 20 per cent. of oxygen, under an additional barometric pressure of 20 cm. There was no

excitement and no material disturbance of the normal functions of respiration and circulation. The anæsthesia was everything that could be desired. On the 13th of July following he announced [6] that by his method he had kept a dog anæsthetised, and free from asphyxial symptoms, for half an hour; that a manometer placed in an artery had not shown any perceptible variations in tension; that the blood pressure had been raised by irritating exposed nerves; that irritation of the peripheral end of the vagus had stopped the heart; and that irritation of its central end had stopped the respiration. On Nov. 11th of the same year Bert made [7] a preliminary report of his results to the Académie des Sciences. On Feb. 15th, 1879, he announced [8] to the Société de Biologie that two days previously his method of producing anæsthesia had been for the first time tried upon the human subject. A large air-tight metal chamber in which, by means of pumps, the barometric pressure could be raised, had been employed, and a mixture of 85 per cent. of nitrous oxide and 15 per cent, of oxygen had been administered from a bag by means of a face-piece with two valves, the barometric pressure in the chamber being 92 cm. (= an increase of 17 cm.). The operation, which was the avulsion of a toe-nail, had been a complete success. There had been no pain,

very little movement, no excitement, a quiet pulse, and no loss of colour. The tension of the nitrous oxide had been $85 \times \frac{92}{75} = 104{\cdot}2$; and that of the oxygen $15 \times \frac{92}{75} = 18{\cdot}4$; in other words, that of the nitrous oxide had been a little higher than when the pure gas was given at ordinary pressures, and that of the oxygen a little lower than that of the air (20·9). Incidentally Bert remarked that such a mixture as that which he employed would not produce anæsthesia at ordinary pressures—a point to which reference will be made later on. Bert's next communication [9] is dated Feb. 21st, 1880. On this occasion he advocated a total barometric pressure of 89·5 cm. and a mixture of similar proportions to those before described.

The almost ideal type of anæsthesia produced by Bert's method attracted such attention, especially on the Continent, that attempts were soon made to obtain similar results without the employment of the costly and cumbrous apparatus which Bert had devised. Thus **Klikowitsch** [10], **Winckel** [11], **Döderlein,** and **Zweifel** employed a mixture of 80 per cent. of nitrous oxide and 20 per cent. of oxygen in obstetric practice, administering the gases as nitrous oxide itself is customarily administered. In most of the cases of which records are available only an analgesic effect seems to have been produced, the patient's consciousness

having remained more or less intact whilst her pains were relieved.

The first systematic application of Bert's method to dental practice was made by Dr. **C. Martin,** of Lyons, whose monographs [12] upon the subject are of interest. Having provided himself with an air-tight metal chamber, and with the necessary machinery for raising the barometric pressure, he proceeded to carry out Bert's directions. He found, however, that by carrying them out to the letter he met with considerable excitement and a "disturbed sleep, barely anæsthetic." The results were, in fact, inferior to those obtainable with nitrous oxide as ordinarily given. He therefore tried an increase of barometric pressure, raising it to 95 cm., 100 cm., and even to 125 cm., but without success. He next tried 12 per cent. of oxygen instead of 15 per cent. as recommended by Bert. Anæsthesia now more rapidly ensued; there was less excitement; there was no cyanosis; and recovery was satisfactory. These results were obtained with a pressure of 105 cm. He next raised the pressure to 110 cm., and for the first time obtained results comparable to those described by Bert. When any excitement began to manifest itself an increase in the barometric pressure quickly arrested it. Martin found it best to wait from 2 to 3 minutes before operating, and in the event

of a long anæsthesia being necessary he administered the mixture for 4 or even 5 minutes before beginning the extraction. It is interesting that he found that if the pressure were only 100 cm. or 105 cm., the patient recovered more quickly than with a pressure of 115 or 120 cm. After-nausea was more frequent in the prolonged administrations than in the others.

The author has elsewhere [13] described an interesting experiment which Dr. Martin made upon a dog. He kept the animal breathing a mixture of 85 per cent. of nitrous oxide and 15 per cent. of oxygen under a pressure of from 110 to 120 cm. for three consecutive days, without any untoward effects during or after the insensibility. Nothing could more forcibly demonstrate the harmlessness of this mixture than such an experiment.

On April 30th, 1883, Bert read his final paper on the subject [14]. Having reviewed his previous work, he stated that he had been endeavouring to produce prolonged nitrous oxide anæsthesia without the employment of increased atmospheric pressure, and that he had been successful in the case of the lower animals. He regarded the alternate administration of nitrous oxide and air as objectionable. He first tried administering nitrous oxide and oxygen alternately; but the rapid elimination

of the former gas in the presence of the latter led to a too sudden recovery. He next administered alternately pure nitrous oxide and a mixture of nitrous oxide and oxygen similar to that which he used in his pressure cases. He was thus able to keep a dog unconscious for half an hour. At the time of his paper he had not tried this method on human beings, nor can the author find any record of his having subsequently done so. He urged surgeons, however, to give it a trial, and stated that he intended to make further experiments as to the best percentages for the mixture.

Dr. **Hillischer,** of Vienna, seems to have been the first dentist to use nitrous oxide and oxygen as a routine anæsthetic in dental practice. His first paper appeared [15] in 1886; his second [16] and third [17] in 1887; and his fourth [18] and fifth [19] in 1890. He suggested that the gaseous mixture should be termed "Schlafgas" from the sleep-like state into which patients pass under its influence. Dr. Hillischer administered nitrous oxide and oxygen in upwards of 15,000 cases and the facts which he brought forward undoubtedly justified him in entertaining such a high opinion of this system of anæsthetisation. In his earlier cases he used gasometers, but in later years he employed a regulating apparatus by which the proportion

of oxygen could be increased or diminished during the administration. He very properly directed attention to the necessity of this plan; for he observed that patients varied very considerably in the percentage of oxygen needed to secure a good type of anæsthesia. Hillischer administered "Schlafgas" to patients of all ages; to those suffering from advanced affections of the heart; to those with diseases of the lungs; and to the subjects of epilepsy and other nervous disorders. He looked upon the gaseous mixture as absolutely without contra-indication, and administered it to every patient irrespective of any morbid state that might be present. He admitted that more experience was needed in administering "Schlafgas" than in giving any other anæsthetic; and there can be no doubt that he was correct. As to the actual percentage of oxygen, he found it best, in most cases, to commence with 10 per cent. and gradually to increase this to 15 or even 20 per cent. In dealing with alcoholic subjects and others who were rebellious to the influence of nitrous oxide with 10 per cent. of oxygen, he reduced the proportion to 5 per cent. or even less. On the other hand, if he found that the breathing became laboured, or that the features assumed a cyanotic appearance, he increased the percentage of oxygen.

Dr. **Witzel**, of Essen-on-the-Ruhr, also administered nitrous oxide and oxygen for a large number of dental operations, and in some interesting lectures which he published [20] in 1889, he strongly urged the advantages of the mixture and the correctness of Hillischer's views.

In 1886 the author of the present work commenced, at the Royal Dental Hospital of London, a series of experimental administrations of nitrous oxide and oxygen at ordinary atmospheric pressures with the object of ascertaining the best method for general use. It would serve no useful purpose to describe the numerous procedures which were adopted. No less than 13 distinct plans were tried, each of which necessitated a different form of apparatus. Those specially interested in the matter will find in another publication [21] a full account of the steps by which the author arrived at the apparatus he introduced in 1894, and which is described in the following chapter. That it should have taken so long to devise a workable method may appear remarkable. But the fact is that, as the experiments proceeded, it became more and more clear that attention had to be paid to the minutest possible details. One of the first points that became obvious was that sudden transitions in the composition of the gases breathed were to be avoided. For example,

no good results could be obtained by suddenly changing from ordinary nitrous oxide to a mixture containing a considerable percentage of oxygen; or from one containing a small to one containing a large percentage; or *vice versâ*. An endeavour was made to ascertain whether any definite percentage of oxygen with nitrous oxide would answer in every case. It was found that in most cases a mixture containing $12\frac{3}{4}$ per cent. of oxygen answered admirably. By its use all asphyxial phenomena were avoided; there was no stertor, jactitation, or lividity; breathing continued without the slightest embarrassment; the natural colour was preserved; and in most cases the anæsthesia was perfect and tranquil. In a certain number of cases, however, excitement and screaming arose, and it became necessary to add pure nitrous oxide to the mixture in order to terminate such cases satisfactorily. The results with this mixture were published in the *Lancet* [22]. The next point that proved to be of importance was the necessity of absolutely excluding air during the inhalation. There can be no doubt that in administering nitrous oxide from a half distended bag a small quantity of air is very likely to gain access to the lungs, either under the face-piece or at the expiratory valve. If, however, nitrous oxide, with or without

oxygen, be administered in such a way that the inhaling bag is kept distended, it is obvious that no such admixture of air can occur. The author was for some time at a loss to account for the better results obtained in administering nitrous oxide and oxygen when the gases issued from the gasometer under slight pressure than when no such pressure was employed. There can be little doubt that the explanation suggested is the true one, and that when the gases are given with a half-full bag small quantities of air gain access to the lungs and disturb the anæsthesia. The admixture of a small quantity of air during an ordinary administration of nitrous oxide is an advantage, at all events in most cases; but it is not so with nitrous oxide and oxygen. It next became clear that, in the absence of a regulating apparatus, 10 per cent. of oxygen was preferable to 12½ per cent., and when this mixture was administered from a distended bag very good results occurred in most cases. It soon became evident, however, that there was no definite percentage of oxygen which in every case would prevent all traces of asphyxia, and yet would in no way interfere with anæsthesia. Patients varied too widely for the employment of any method of this nature. It was obviously necessary to have control over the percentage of oxygen, so that it could be

increased or diminished during the administration, in accordance with the needs of the case. The author therefore tried various kinds of regulating apparatus which he devised. He also tried Hillischer's apparatus; but the results obtained with it were not satisfactory. Its chief fault seemed to be that it did not allow of fine enough adjustment in its oxygen inlet. The channels through it, moreover, were of small calibre, the bags were too far from the mouth-piece, and the valves did not work with that perfect freedom which is essential.

The first apparatus with which the author obtained reliable results was described by him before the Odontological Society in 1892 [21], and the effects produced by that apparatus were demonstrated [23] by him before the British Dental Association at Manchester in the same year. It is unnecessary to refer to its mechanism here, as the apparatus was similar in its main principles to that which is considered in the following chapter.

The apparatus about to be described was brought before the notice of the British Dental Association at Newcastle-on-Tyne in 1894 [24]. When it has been described the effects which it produces will be considered in detail.

CHAPTER II.

APPARATUS.

1. Gasometer Methods.

Whilst it is true, as already stated, that there is no definite percentage of oxygen which will answer satisfactorily in every case, and that to obtain the best results a regulating apparatus is essential, it is equally true that **a continuous administration of certain known mixtures of the two gases by means of a gasometer** will produce far better results than can be obtained by nitrous oxide alone.

The question hence arises: What percentage of oxygen should be used in gasometer administrations? In the course of an investigation [25] which the author conducted at the Royal Dental Hospital of London, one object of which was to settle this question, he administered nitrous oxide with the following percentages of oxygen:—

	CASES
Nitrous oxide with 3 per cent. of oxygen	5
,, ,, 4 ,, ,,	10
,, ,, 5 ,, ,,	17
,, ,, 6 ,, ,,	11

	CASES
Nitrous oxide with 7 per cent. of oxygen	11
,, ,, 8 ,, ,,	18
,, ,, 9 ,, ,,	5
,, ,, 10 ,, ,,	10
,, ,, 11 ,, ,,	7
,, ,, 13 ,, ,,	2
,, ,, 20 ,, ,,	4
	100

These mixtures were accurately prepared and accurately administered under precisely similar circumstances by means of an apparatus with accurately working valves, great care being taken to exclude all atmospheric air. Records were obtained with regard to: (1) The duration of inhalation necessary for the production of anæsthesia for a short dental operation; (2) the average duration of after-anæsthesia; (3) the average quantity of the mixture used; (4) the degree of "jactitation" (anoxæmic convulsion); (5) alterations in the colour of the features; (6) stertor; (7) phonation; (8) reflex and excitement movements; and (9) after-effects. The duration of inhalation increased in proportion to the amount of oxygen in the mixture. Thus, with 3 per cent. of oxygen the average inhalation period was 96·6 seconds; whereas with 20 per cent. of oxygen it was 223·5 seconds. Deep anæsthesia was obtainable

even when the proportion of oxygen was as great as in atmospheric air. The after-anæsthesia was longer than when mixtures of nitrous oxide and air were employed. The best results, so far as a lengthy available anæsthesia was concerned, were met with when using 7 per cent. of oxygen, the average duration of after-anæsthesia with this mixture being 50·1 seconds. Anoxæmic convulsion was readily prevented even by comparatively small percentages of oxygen. During the inhalation of nitrous oxide, either pure or with oxygen up to 4 per cent., some degree of jactitation was common; but when once 5 per cent. of oxygen had been reached very little convulsive movement was observed and with 6 per cent. and over no such movement was obtained. The author found that with less than 11 per cent. of oxygen some degree of lividity of the features was usually present; but with this percentage and over the normal colour was retained. The effects of even small percentages of oxygen in preventing stertor were marked. Thus with 3 per cent., 4 per cent., and 5 per cent. of oxygen the ordinary stertor met with under pure nitrous oxide lost its irregular character and became replaced by a regular snoring sound, similar in its type to that of ether or chloroform anæsthesia. With 20 per cent. of

oxygen snoring altogether vanished. Phonated sounds were less common under nitrous oxide and oxygen than under nitrous oxide and air mixtures. They were commonest with very small and with very large percentages. Reflex and excitement movements were uncommon with small percentages of oxygen

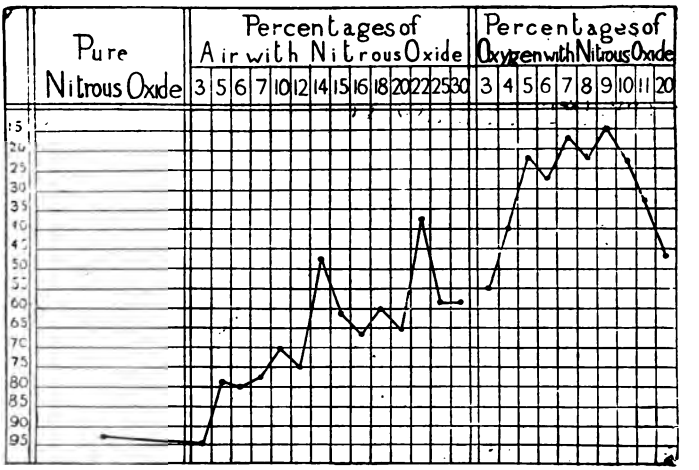

FIG. 1.—Chart showing comparative general results obtained by (*a*) pure nitrous oxide, (*b*) nitrous oxide with different percentages of air, and (*c*) nitrous oxide with different percentages of oxygen. Arbitrary Numerical Scale.—Perfect type = 0; failure to produce anæsthesia = 2CO.

but often asserted themselves and occasionally became inconvenient when the proportion of oxygen rose to 10 per cent. or more. Stamping, kicking, side to side movements, &c., were common with from 10 to 20 per cent. of oxygen.

As regards the general result, the best mixtures for adult males were those containing 5, 6, or 7 per cent. of oxygen; and mixtures containing 7, 8, or 9 per cent. were best for adult females and children.

The accompanying chart shows the comparative general results obtained by (*a*) pure nitrous oxide, (*b*) nitrous oxide mixed with different percentages of air, and (*c*) nitrous oxide mixed with different percentages of oxygen.

The chief objections to the use of definite mixtures of nitrous oxide and oxygen are: (1) That they are difficult to prepare with accuracy and in sufficiently large quantities; (2) that different subjects require different percentages; and (3) that the proportion of oxygen cannot be increased or decreased to meet special conditions arising during the administration. At the same time, it is important to have a clear idea of the effects produced by different proportions of oxygen, in order that we may correctly understand all the phenomena which may arise during the use of varying percentages of the two gases by means of the apparatus to be presently described.

A word of caution is perhaps necessary with regard to keeping nitrous oxide and oxygen together, in gasometers, for any length of time. Hillischer stated that traces of the higher

oxides of nitrogen were detected at the end of a week, in a mixture which had been kept in Ludwig's laboratory. The two gases should, therefore, be mixed as required.

2. THE AUTHOR'S REGULATING APPARATUS.

Before describing this in detail it may be well briefly to enumerate the various **requirements** which must be fulfilled by any regulating apparatus for the administration of nitrous oxide and oxygen. They are as follows:—

(1) There must be a plentiful supply of the two gases from easily and quietly working cylinders:

(2) The bags into which the gases pass must be capable of being kept partly and equally distended during the administration:

(3) The bags must be as close as possible to the face-piece:

(4) The channels throughout the apparatus must be sufficiently large to avoid any stress whatever being thrown upon respiration:

(5) The regulating portion of the apparatus must allow of very small increments and decrements in the proportion of oxygen breathed with the nitrous oxide:

(6) There must be accurately working valves: (*a*) for preventing all re-breathing, and (*b*) for preventing diffusion between the contents of one bag and the contents of the other:

(7) The expiratory valve must not allow of any air being sucked back during its closure in the inspiratory phase:

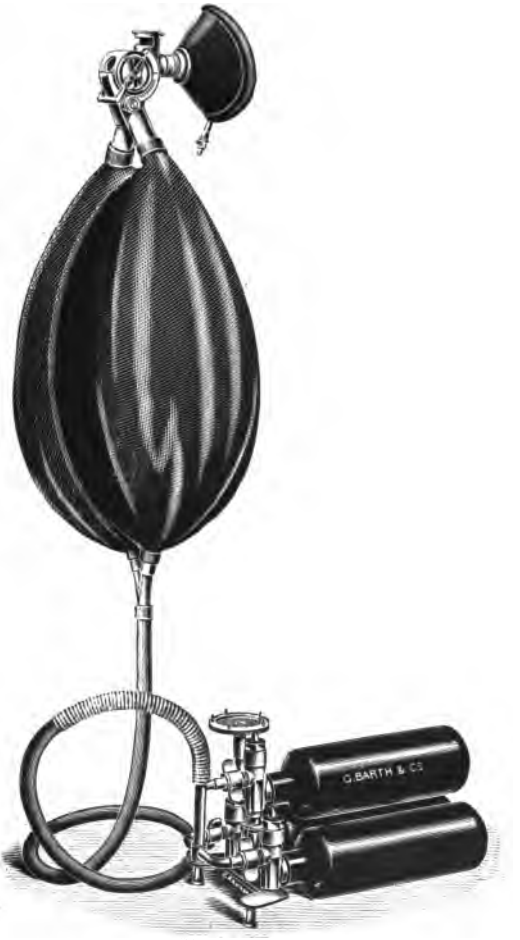

FIG. 2.—The Author's Apparatus.

(8) The apparatus must be so constructed that when first applied to the face air will be

breathed freely through it, and through the same valves that will subsequently be used when the mixture is turned on:

(9) The apparatus must admit of being taken to pieces readily without the use of tools, so that its various parts may be inspected when necessary.

(10) The inhaling portion of the apparatus must admit of being thoroughly cleansed and of being treated with antiseptic solutions should occasion require.

(11) The whole apparatus must be sufficiently portable to be carried in a hand-bag. (see fig. 6, p. 44.)

Fig. 2 represents the **complete apparatus.** It consists of **two nitrous oxide cylinders, one oxygen cylinder, a combined stand and union, double india-rubber tubes** (one running inside the other) for conducting the two gases from the cylinders to the bags, **two india-rubber bags** joined together by a septum common to both, a **combined regulating stop-cock and mixing chamber,** and a **face-piece.**

The two **nitrous oxide cylinders,** the single **oxygen cylinder** resting upon them, and the combined **stand** and **union,** are shown in diagrammatic section in fig. 3. Each nitrous oxide cylinder will furnish 50 gallons of nitrous oxide gas; and each oxygen cylinder about 15 gallons of oxygen. The combined stand

and union is so made that the cylinders can be connected together or disconnected without the aid of spanners or other appliances. In order to prevent undue strain to the union when the foot-key is being used upon the oxygen cylinder, an adjustable screw pillar, fixed to the stand below, is made to engage that part of the under surface of the oxygen

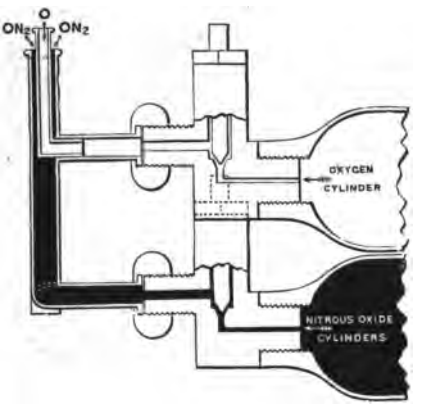

FIG. 3.—Diagrammatic section of cylinders and of combined stand and union.

cylinder upon which foot-pressure directly tells. In this way all foot-pressure is transmitted to the stand. When the foot-key is placed upon one of the nitrous oxide cylinders and is turned, the liberated nitrous oxide passes to its bag through brass and india-rubber tubes of comparatively large calibre. When oxygen is similarly released from its cylinder it passes to its bag through brass and india-rubber

tubes which are so much smaller than the nitrous oxide tubes that they are made to travel inside the latter. Thus, in fig. 3, it

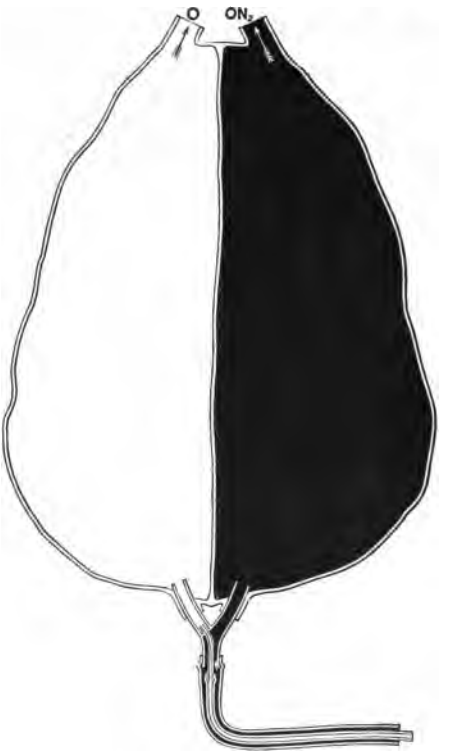

FIG. 4.—Diagrammatic section of the india-rubber transmitting tubes and bags through which the two gases pass on their way to the regulating stop-cock and mixing chamber.

will be seen that in the combined stand and union the metal transmitting tube for the oxygen is inside that for the nitrous oxide.

Fig. 4 shows, in diagrammatic section, the

two india-rubber **transmitting tubes,** one inside the other, conveying their respective gases to the two india-rubber **bags.** These bags are of about equal capacity, and are so made that a rather thick india-rubber septum is common to both. When full they have the outward appearance of a single bag. Care is needed to prevent the india-rubber from becoming punctured or otherwise injured. Even if only one or two minute punctures exist, they may be quite sufficient to allow of an admixture of atmospheric air. The bags, moreover, must not be too small; otherwise it may be difficult or impossible, during the administration, to keep the nitrous oxide bag equal in size to the oxygen, especially if the patient should breathe very deeply.

The **regulating stop-cock and mixing chamber** is shown in detail in fig. 5. The nitrous oxide bag (see fig 4) is attached to the tube NOT, the orifice of which, NOO, is shown. The oxygen bag is attached to OT, which communicates above with a little oxygen chamber OC. There are ten minute holes between the oxygen chamber, OC, and the mixing chamber. Only three of these ten holes, OO, appear in the figure. All the ten oxygen orifices are of the same size except the first, and by means of the supplementary stop-cock, SS, this can either be made of the same size

as the other nine (first position of SS) or it can be made equal to the ten orifices collectively

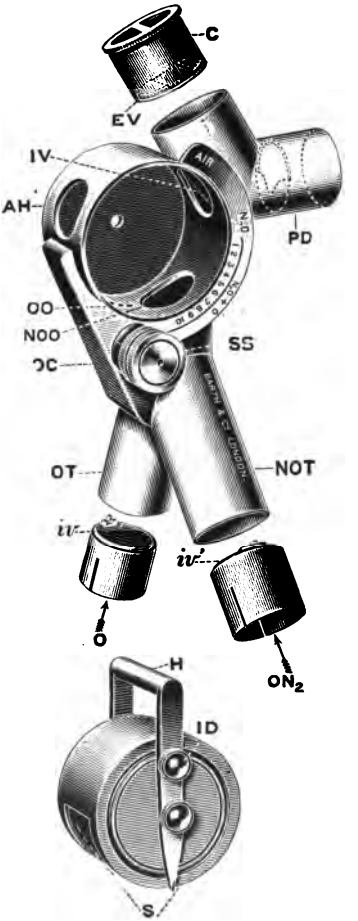

FIG. 5.—Regulating stop-cock and mixing chamber.

(second position of SS), or to twenty such orifices (third position of SS). The tubes OT and NOT are furnished with removable

valves, *iv* and *iv'*, which act during inspiration, and which prevent diffusion between the gases of the two bags. AH is the air-hole. IV is the main inspiratory valve. EV is the expiratory valve, with its chimney C. PD, shown in dotted outline, is a partial diaphragm, mounted upon a removable inner tube, which serves to direct the expirations towards the expiratory valve EV. In the absence of this partial diaphragm there is a tendency for the expirations to pass back again beneath IV, and so to throw the valve-action completely out of gear. The chimney C is essential in preventing air being drawn back through EV during its closure at each inspiration. The inner drum, ID, which is made to revolve by means of the handle H, has a large portion of its circumference cut away to form a long slot S. The handle H is prolonged into an indicating point or indicator. To the circumference of the stop-cock and mixing chamber is fixed a flange with "AIR," "N_2O," and "$N_2O + O$," engraved upon it. There are also figures, from "1" to "10" inclusive, belonging to the "$N_2O + O$" part of the flange, When the indicator of the handle H points to "AIR" as in Fig. 2, the slot S of the drum ID allows air to pass through AH and IV during the act of inspiration; but by reason of the other part of the drum covering the orifices NOO and

OO nothing but air is breathed. When the indicator is moved to "N_2O," the drum closes AH and opens NOO, the oxygen orifices still remaining covered. Pure nitrous oxide is therefore inhaled. When the indicator reaches "1" on the "$N_2O + O$" part of the flange, the nitrous oxide orifice NOO still remains open, but in addition, the first oxygen orifice OO becomes uncovered by the revolution of the inner drum. When "2" is reached, two oxygen holes are open, and so on up to "10," the nitrous oxide orifice remaining patent throughout. It may thus be said that directly the indicator is made to point to "N_2O" there passes through the stop-cock a continuous and large stream of nitrous oxide, and that as the indicator is moved to 1, 2, &c., any number of small streams of oxygen (from 1 to 10 inclusive) may be added to this continuous stream of nitrous oxide. As the first of the oxygen orifices may be made, by rotating the supplementary stop-cock SS, ten or twenty times its ordinary size, it follows that the administrator can add at will quantities of oxygen corresponding to 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, or 29 orifices. A very fine adjustment in the oxygen supply is thus effected. As the indicator reaches the various points on the flange an audible click is pro-

duced by means of a spring attached to the handle.

All the **valves** are made of thin sheet india-rubber, and it is important to keep them in good order. Should they become inelastic from age, or in any way fail to act, as they are intended to act, with perfect accuracy, the apparatus will not produce good results. For example, an apparatus may let through much larger proportions of oxygen than usual if the nitrous oxide valve *iv'* should happen to adhere along a part of its circumference to the rim upon which it rests; the explanation being that the suction exerted by the inspirations of the patient would have a greater influence than usual in drawing oxygen from the oxygen bag owing to the abnormal resistance at the nitrous oxide valve. The valves of the apparatus are so arranged as to act most efficiently when the main expiratory valve is kept as horizontal as possible. If the whole apparatus be much tilted during use, as would be the case if the patient's head were thrown very far back, the valves may not act efficiently.

The apparatus may be taken to pieces with the utmost readiness by simply removing, with the finger, the screws which connect the handle H to the inner drum ID. In this way the drum may be removed and the valves and

oxygen orifices inspected. The latter may occasionally require to be freed from dust.

Three or four **face-pieces** of different sizes should be at hand. The air-cushion of the face-piece employed should be only moderately inflated, otherwise it may not fit as well as is desirable.

In order that good and reliable results may be obtained, it is important that the whole apparatus should be carefully handled. The process of anæsthetising with nitrous oxide and oxygen is a more delicate process than that involved in the ordinary administration of nitrous oxide alone ; and trifling defects in the apparatus are liable to interfere with results. The connections must be tested ; the bags inspected frequently ; the stop-cock taken to pieces occasionally—in fact, the anæsthetist must take a personal interest in his apparatus if he wishes to succeed with it.

A word may here be said as to the **relative proportions of nitrous oxide and oxygen** which the apparatus is capable of furnishing. As will be pointed out in the following chapter much will depend upon the physical conditions of the two bags during the inhalation, and especially upon whether they are kept of equal size throughout. But it is necessary to mention, in the present connection, that each apparatus will be found to possess slight but

special peculiarities of its own. It is a difficult matter to produce two models which will act in precisely the same way. It therefore follows that the anæsthetist must observe what his particular apparatus is capable of doing. With one model it may not be possible to reach "8" upon the flange without excitement arising; whilst with another model "9" or "10" may be reached in nearly every case without any such symptoms occurring. But when once the anæsthetist has found out how far he can go with his particular apparatus he will always be able to depend upon it working in the same way, provided of course that he keep its valves, oxygen holes, bags, and other parts in good order.

The apparatus is manufactured only by Messrs. Barth and Co., of Poland Street, Oxford Street, to whom the author is much indebted for the patience and skill they have shown in carrying out his designs. It may either be obtained from them, or from Messrs. Ash & Sons, Broad Street, Golden Square.

CHAPTER III.

PREPARATIONS.

THE old adage, "Everything that is worth doing is worth doing well," forcibly applies to the use of anæsthetics in dental practice. It is only by attention to detail that success can be achieved in every case. The dentist who regards preparations and precautions as unnecessary, and who expects his colleague to entertain similar views, has only himself to thank when difficulties arise. There is no known method of anæsthetising which will succeed when the corsets are tightly laced, the stomach full, or the posture faulty. It is a mistake to suppose that patients are made nervous by the few preparations which are essential to success. They are just as likely —and perhaps more likely—to gain assurance when they see that pains are being taken to obtain the best results.

Diet.—When practicable, **an interval of at least four hours** should have elapsed between the last meal and the administration. The middle of the day (from 12 to 2 o'clock) is a very convenient time for the extraction of

teeth under anæsthetics. Precautions as to diet are especially important in the case of children, and when a long anæsthesia is needed. **Milk** is particularly liable to produce unfavourable symptoms during and after anæsthetisation and should strictly be avoided on the day of the administration (see p. 93).

Stimulants should, as a rule, be withheld. In very feeble subjects, however, and in those inclined to faint, an exception may be made if desired. The author has notes of a case in which a child was given by his parents some brandy and water before starting for the dentist's. A very unsatisfactory anæsthesia followed, and the little patient retched violently. On the other hand he has notes of another case in which three teaspoonfuls of brandy in a little water, ten minutes before the administration, answered exceedingly well. The patient was a pale, nervous youth of 16, so apprehensive that it was at first impossible to induce him to take an anæsthetic. The appointment was postponed for two hours, at the end of which time the brandy was administered with the result that, in ten minutes, both the pallor and the nervousness had vanished, and the anæsthetic was taken satisfactorily.

When circumstances permit, it is well that the **bladder should be emptied** before the administration. Micturition is, however, exceedingly rare.

Whenever circumstances are favourable, it is a good plan to have **everything in readiness** before the patient enters the room. The anæsthetist should see that his apparatus is in working order; he should half fill the bags with their respective gases, so that they are equally but only partly distended. He should leave the foot-key on one of the nitrous oxide cylinders ready for use.

The following appliances should always be in readiness: **Mouth props** of various sizes, a **Mason's gag**, a pair of **tongue forceps,** some **nitrite of amyl** capsules, and **instruments for performing tracheotomy.** Although the author has never had occasion to use tongue forceps, nitrite of amyl, or tracheotomy instruments in connection with this form of anæsthesia, he would strongly urge the importance of being fully prepared for all contingencies.

A **third person** should always be present in the room from the time the inhalation is begun till the patient's consciousness is fully restored.

The administration should not be undertaken by the same person who performs the operation.

The importance of **loose clothing** cannot be too strongly insisted upon. In order that the induction of anæsthesia may successfully be accomplished, it is necessary that the air

in the lungs should be exchanged as quickly as possible for the anæsthetic gas. In order that this may be effected, the *bases of the lungs must expand by diaphragmatic action.* If there be tightly-fitting corsets or waistbands, the diaphragm cannot descend fully; the breathing will be restricted, and to a great extent or entirely thoracic; interchange between the air in the lungs and the anæsthetic will only take place freely in the upper parts of the lungs; and the onset of anæsthesia will, therefore, be delayed. Patients who are tightly laced may do their best quickly to fill their lungs with the anæsthetic gas, but they will fail. All constricting clothing about the upper part of the chest and neck should also be loosened with the object of allowing respiration to proceed perfectly freely. It is not a bad plan for ladies to come to the dentist's loosely attired, so that no further preparation in this direction need be made.

The **posture** of the patient has a decided influence in modifying the phenomena of anæsthesia. The author has elsewhere entered at length into this subject, and would refer the reader to his paper [26] specially dealing with it. Whenever circumstances permit, the patient should be allowed to assume a comfortable and unrestrained posture, and his head should be permitted to retain its natural position in

regard to the body, being neither flexed upon the chest nor extended towards the spine (see fig. 6, p. 44). Good results cannot be expected if the administration be begun when the patient's head is thrown far back. Should the operator wish to have the head thrown more backwards than is represented in the figure, the best plan is to anæsthetise the patient in the posture depicted, and to tilt the whole chair backwards just before the face-piece is removed for the commencement of the operation. In this way the proper angle for the operation will be obtained without disturbing the normal relations of the head to the trunk. Should the chair not admit of this movement, or the operator require some degree of extension of the head, a small cushion may be placed under the head, and subsequently removed; or the head-rest may be lowered just before the operation begins. The position of the legs and feet is also important, especially in the case of tall, muscular men who not unfrequently become rigid. If there be a foot-rest that can be raised to about the level of the seat of the chair, the legs and feet should be so adjusted that the former are perfectly straight whilst the latter project slightly beyond the rail, the tendo Achillis of each foot resting upon the rail. By this arrangement any reflex straightening of the body will not involve

movement of the head. If there be no foot-rest, or if the foot-rest does not admit of being raised, a small ordinary chair should be stood over the foot-rest in such a way that the back of the chair is parallel to the legs of the patient, and the legs should be adjusted horizontally with the feet projecting slightly beyond the side of the chair. The hands should rest comfortably in front of the patient with the fingers interlaced.

Should **relatives** or **friends** express a desire to be present during the operation, they should not be permitted to stand near the chair, nor to hold the patient's hand, as such attentions will almost certainly have an opposite effect to that which is intended, and introduce a disturbing element into the anæsthesia. In many cases friends wish only to be present during the induction stage, and there is little to be said against this; directly consciousness has been lost, a signal should be given them in order that they may retire during the actual operation. Owing to the fact that by the use of oxygen with nitrous oxide a far more tranquil and sleep-like anæsthesia is produced than with nitrous oxide alone, there is less objection to friends being present than under other circumstances.

A suitable mouth-prop should be inserted immediately before the administration is begun.

The prop employed by the author is described elsewhere [13]. It is made of aluminium, and is so shaped that it rarely if ever slips when once put into position. Props should always be sterilised beforehand by boiling. It is important in fixing the prop that the mouth should be opened as widely as possible, except when stretching the lips would inconvenience the operator, or when widely opening the mouth would give the patient great discomfort, or excite retching movements. In the extraction of wisdom teeth it is usually a good plan not to open the mouth to its fullest extent. Should the insertion of the prop excite retching movements, the remedy which usually answers is an exceedingly simple and efficient one. The prop having been inserted, the patient should be requested to breathe deeply through the open mouth, to count his respirations to himself, and to concentrate his whole attention upon the counting. The face-piece is then quickly applied, the gases admitted, and if the patient continue to fix his attention as suggested, he will pass into anæsthesia without the recurrence of any retching movements.

CHAPTER IV.

THE ADMINISTRATION.

WITH the object of making this part of the subject as clear as possible, it will be well to confine our attention in the present chapter to the details of **an ordinary or average administration,** and to the effects which such an administration produces in **an ordinary or average patient.** As the majority of those who require anæsthetics in dental practice are women, it will be advisable to take as our normal type a young woman of medium height and build, of medium complexion, and not markedly nervous. When we have fully considered the method which should be adopted in anæsthetising such a patient we shall be in a position to discuss, in a subsequent chapter, the slight modifications in procedure which are essential in dealing with other types of patients.

An endeavour should be made to **avoid all disturbing influences** during the administration. The room should be kept quiet.

Friends should not be permitted to hold the patient's hand. The anæsthetist should say a few words to the patient during the first few moments of the inhalation, but not a word

FIG. 6.—The administration.

should be uttered after this until the operation has been completed. The anæsthesia is likely to be disturbed by any conversation, loud noises, the comments or questions of

anxious friends, &c. Even feeling the pulse at the wrist is likely to induce nervousness, and should be avoided. In a word, the less said the better.

When considering in Chapter III. the preparations which are necessary before an administration is commenced, it was stated that the bags containing the nitrous oxide and oxygen should, if possible, be charged with their respective gases, and that the foot-key should be placed upon one of the nitrous oxide cylinders before the patient enters the room.

Before the face-piece is actually applied, the patient should be asked to commence breathing backwards and forwards through the **mouth**. As the majority of one's patients either seem to be ignorant of the difference between oral and nasal breathing, or to have difficulty in restricting the respiratory current to the mouth, it is often a good plan to demonstrate the type of breathing desired by making one's own breath pass audibly through one's lips. When the anæsthetist is satisfied that the patient is breathing freely through the mouth he should gently but accurately adapt the face-piece. Air will still be breathed, but through the easily acting valves of the apparatus (fig. 6). Should there be the slightest doubt as to the continuance of strictly oral respiration the patient should be requested to breathe out

through the mouth as if desirous of making the breath visibly condense upon a mirror. The most absolute coaptation of the face-piece is essential. The sound made by the flapping of the valves is the best proof that the face-piece is fitting well.

When it is clear that the face-piece fits accurately, and that the patient is breathing air freely through the mouth, **the indicator,** which has hitherto been pointing to "AIR," **should be turned to "2."** At the same moment the foot should slightly turn the foot-key in order quickly to replace the nitrous oxide which the patient is now commencing to breathe. It is difficult to state with precision what percentage of oxygen will come through when the indicator is thus turned to "2," for one apparatus will be found to differ slightly from another, and much will depend upon the relative sizes of the bags at the moment. It is sufficient for our purpose that quite a small percentage—roughly about 1 or 2 per cent.—will be breathed. The percentage is so small, indeed, that the oxygen bag hardly appears to alter in size throughout, and no further addition to it from the oxygen cylinder is usually necessary in dental administrations, even in the case of long inhalations.

The **initial sensations** of the patient are

similar to those experienced under nitrous oxide itself. There is, however, one important difference, namely, that the small quantity of oxygen accompanying the nitrous oxide to the lungs usually prevents all feelings of suffocation, provided that the patient breathe through the mouth and that the valves act freely. There is, moreover, less tinnitus than with the pure gas; whilst the distressing feeling that the head is bursting—so often complained of after ordinary nitrous oxide administrations—is rarely if ever experienced. It may be said, in a word, that provided the clothing be absolutely loose and that the patient breathe freely through the mouth, the administration of nitrous oxide and oxygen may be conducted without any discomfort. Consciousness is not lost quite so quickly as with pure nitrous oxide.

The anæsthetist has now to pay attention to **three points** at the same time. He has (1) to keep the face-piece very accurately applied; (2) to keep the two bags equally and only partly distended, and (3) to increase or diminish the proportion of oxygen according to the symptoms of the patient. It will therefore be advisable to consider the remaining part of the administration under these three heads.

(1) **The fitting of the face-piece.** Whilst

there is much to be said in favour of the face-piece as opposed to the mouth-tube for nitrous oxide inhalation, there can be no doubt that it is more difficult, when employing the former, to completely exclude atmospheric air. There are, however, several objections to mouth-tubes. The idea of holding between one's lips a tube that has just been used by another patient is not a pleasant one, even though the most scrupulous cleanliness may have been enforced. Moreover, it is essential in using a mouth-tube that the nose should be clipped or held in order to prevent any air entering the nasal passages. And, lastly, breathing is liable to be impeded by the tube necessarily being of small calibre. Taking everything into consideration, therefore, the face-piece has distinct advantages. But considerable practice is required before perfect coaptation can be secured in all cases. Unfortunately, when employing the mixed gases, any want of coaptation cannot be met by increasing the pressure at which the gases enter the face-piece, for distension of the bags would at once render the regulating mechanism ineffective.

(2) **The fulness and relative sizes of the bags.** In order that the regulating mechanism may work properly it is necessary that the two bags should be kept as nearly as possible of equal size throughout, and only partly dis-

tended. The anæsthetist has, in fact, to use his foot as much as his hand, and to let in nitrous oxide to its bag in such quantities that the bag remains the same size as the oxygen bag. The latter necessarily grows gradually smaller, and the anæsthetist, therefore, has to keep the nitrous oxide bag less and less full.

(3) **The admission of oxygen.** Given that the apparatus works satisfactorily and in the usual manner, the anæsthetist must regulate the admission of oxygen in accordance with the type of his patient, and with the symptoms displayed. There is, unfortunately, no rule which will apply to every case. After some experience the administrator will recognise that he has at his disposal an apparatus by which he can, if he wish, obtain two totally different groups of symptoms. If very little or no oxygen be given, the ordinary phenomena of nitrous oxide narcosis will present themselves, viz., blueness, lividity, or duskiness of the features, epileptiform twitching of the muscles of the trunk, extremities, and face, and obstructive stertor. If too much oxygen be admitted, there will be no alteration in colour, no epileptiform convulsive movements and no stertor, but mental and muscular excitement (laughter, shouting, kicking, stamping, and struggling) may attend the administration, and be almost

as objectionable as the asphyxial phenomena produced by pure nitrous oxide.

There are thus two extremes—two ends of the scale—and each extreme must be avoided. The anæsthetist has, in fact, to steer a middle course, and to keep a sharp look-out. A little practice will enable him to avoid the Scylla of asphyxia on the one hand and the Charybdis of excitement on the other. He will find, after a time, that he is able to detect even slight deviations from the proper course, almost before such deviations have taken place. Generally speaking, a gradual and progressive increase in the percentage of oxygen is advisable. In such a case, for example, as that which we have pictured to ourselves, the best results will be obtained by starting the inhalation, as already mentioned, with about 1 or 2 per cent. of oxygen, and then progressively increasing the proportion to 8 or 9 per cent. It would seem to be a mistake to adopt the plan recommended in Germany and to begin with as much as 10 per cent. of oxygen. It is surely more rational to make an allowance for the oxygen present in the lungs when the administration is commenced, and to begin with a very small percentage of this gas. As the lungs lose the air they contain, so the percentage of oxygen in the mixture may be increased, provided that no symptoms of ex-

citement arise. If a 10 per cent. mixture be used from the commencement, excitement is liable to ensue from the undue proportion of oxygen. Witzel [20], for example, who followed this course in his administrations, found it necessary to employ arm-rings, foot-straps, and other appliances to restrain the patient's movements, and to have at hand on all occasions strong and trained assistants. Such precautions are unnecessary when the method here advocated is followed. The author finds it best, as a general rule, to allow two or three inspirations of the mixture to take place with the indicator at "2"; two or three more with it at "3"; two or three more with it at "4"; and so on till "6" or "7" is reached. When the breathing is shallow the admission of oxygen must be more gradually effected than when the breathing is deep. Usually by the time the indicator has reached "6" or "7" the anæsthetist will be able to recognise the existence of one of three conditions. There will either be evidence to show

(α) That the proportions of the two gases are **properly adjusted**;

(β) That the proportion of oxygen is rather **in excess** of that which is needed, and should therefore be diminished; or,

(γ) That this proportion is rather **less** than that required, and should therefore be increased.

(α) The absence of any indications of excitement on the one hand, or of asphyxia on the other, will prove that the proportions of the two gases are properly adjusted. Under such circumstances the indicator may either be kept at "6" or "7" for several breaths, and then gradually turned to "8," "9," or "10," or it may be allowed to remain at "6" or "7," till anæsthesia is fully and satisfactorily established.

(β) Should there be an unaltered colour, associated either with slight phonation, hardly perceptible breathing, a tendency to laughter, or slight restless movements of the head, trunk, or extremities, the oxygen indicator should be turned back slightly; for these symptoms indicate that too much oxygen has been inhaled.

(γ) Should the breathing be loudly snoring in character, or the colour rather dusky, or should slight general clonic movement of the body, head, or extremities be evident, the oxygen indicator must be moved on; for such symptoms indicate a deficiency of oxygen.

In one or other of these three ways the patient will pass into **deep and satisfactory anæsthesia characterised by certain definite phenomena.** The experience of recent years has convinced the author that in administering nitrous oxide and oxygen an endeavour should be made to obtain an anæsthesia

similar in most of its features to the best types of ether or chloroform anæsthesia. If an attempt be made to induce a perfectly sleep-like state in which the colour of the features is absolutely unaltered or is even heightened, and the breathing is so tranquil that it is inaudible, there will not only be a liability to excitement, but the anæsthesia will, at all events in many cases, be less profound than is desirable. Moreover, it is not an easy matter, when the breathing is inaudible, to estimate the depth of anæsthesia. An endeavour should therefore, be made to bring about an anæsthesia characterised by **softly snoring breathing, a good pulse, a colour as near the normal as possible, an insensitive ocular conjunctiva, relaxed eyelids, a fixed condition of the globes, and the absence of muscular rigidity in the extremities.**

Sometimes, and especially after a phase of rapid breathing, or when a good deal of oxygen has been given, the **respiration may come almost or completely to a standstill** without there being the slightest need for alarm. The apnœic state is associated with a good pulse and colour, and will quickly pass off when the proportion of oxygen is reduced.

The **pulse** is always as quick as, or quicker than it was immediately before the adminis-

tration. In most cases the initial acceleration from nervousness gradually increases to a maximum, and then declines somewhat, though it never falls below its initial acceleration rate. The author is unable to agree with Hillischer's observation that the pulse-rate sinks to normal during anæsthesia. Dr. Oliver [27] observed, in using his arteriometer, that the pulse calibre was not reduced as in the case of pure nitrous oxide. The small, feeble, and exceedingly rapid pulse which not unfrequently may be felt at the acme of an ordinary nitrous oxide inhalation, is not met with when oxygen is present in sufficient quantities with the nitrous oxide. The author has never met with any marked indications of primary circulatory failure during the administration of the mixed gases. The tongue and adjacent structures are less engorged than when nitrous oxide is administered free from oxygen.

The **eyes** are generally closed throughout. Some patients, however, prefer to keep them open when the inhalation begins, but as it proceeds, the globes gradually cease to fix themselves on surrounding objects, and the lids become approximated. During the first minute or so of the inhalation any attempt on the part of the administrator to raise the upper lid will be resisted by the patient; but after the first minute the lid will gradually relax, and when

it can be raised without any resistance, and the conjunctiva touched without reflex response, it may generally be assumed that sufficient anæsthesia is present. Sometimes fine oscillatory movements of the globes may be seen on raising the upper lids. The pupils are generally of medium size or moderately dilated. There is a striking contrast between the closed lids of this form of anæsthesia and the open and turned-up eyes so often seen in ordinary nitrous oxide narcosis.

Amongst the numerous points to which attention must be paid in conducting the administration, there is one which is of considerable importance. It is that the anæsthetist must allow for what may be termed the **delayed effects** of admitting more or less oxygen. For example, let us suppose that slight phonation occurs when the indicator points to "7." By turning it to "3" or "4" the phonation will in the course of a few moments subside. But if the indicator be kept at "3" or "4" till the patient is perfectly quiet, the anæsthetist will probably have gone too far in the asphyxial direction. He should turn to "3" or "4" for a few breaths only, and return to "5," "6," or "7" before the phonation has ceased. In other words, he must bear in mind that a little interval must necessarily elapse before the effects of an

increase or decrease in oxygen admission will become manifest.

As regards the **length of inhalation** requisite for the production of the typical phenomena of anæsthesia, the author has found that it is, on the average, 110 seconds, *i.e.*, nearly twice the length of the average nitrous oxide inhalation. The juncture at which the administration should be terminated must, however, depend upon the circumstances of each case, such, for example, as the type of subject, the susceptibility or insusceptibility which the patient has displayed, the nature of the proposed operation, and the length of time that has elapsed since food was taken.

The **quantity of the mixture required** to produce anæsthesia will likewise vary considerably, being dependent upon the proportion of oxygen employed, the depth and rate of respiration, the length of inhalation, the type of patient, and other factors.

CHAPTER V.

THE PATIENT.

In studying the effects produced in the human subject by nitrous oxide and oxygen, one of the first facts to become apparent is that, although the constitution of the mixture, the method of administration, and other surrounding circumstances may remain the same, different individuals will display different phenomena. To say, however, that every case has its own special peculiarities is hardly correct. By careful observation it becomes possible to group cases together into classes, and to say that patients of this or that class will display this or that set of symptoms under precisely similar conditions. We are in this way led to speak of **different types of patients.** It is true that our knowledge of this interesting aspect of the subject is still very meagre; but it is rapidly increasing. Success in administering anæsthetics is largely dependent upon the power the administrator possesses of correctly foretelling what effects this or that method will produce in the patient before him; and it is this kind of knowledge which is essential in

deciding upon the particular lines of treatment which should be adopted in anæsthetising patients by the method now under consideration.

In the preceding chapter we discussed the plan which should be followed in dealing with those types of subjects most commonly met with. We have now to consider what modifications in that plan are advisable when anæsthetising patients of other types.

Sex and age. — In anæsthetising small children, more oxygen than usual may be admitted. Should crying take place, it is best to commence the administration with the indicator at "8," "9," or "10"; for the crying tends to introduce an asphyxial element, and this must be counteracted. The author has anæsthetised two or three children of three years of age by means of the mixture, but with moderate success only, the anæsthesia having been very transient. In older children the indicator may usually be placed at "3" or "4" to commence with, and moved on rather more quickly than usual to "5," "6," &c. By the time "10" has been reached, the breathing will probably have become so tranquil that some doubt as to the presence of anæsthesia may be felt. The indicator should therefore be turned back till snoring commences, when the face-piece should at once be removed.

In this way a more satisfactory anæsthesia will result than if the face-piece be removed during the inaudible breathing.

Taken as a class, women are better subjects than men. They are more tolerant of considerable proportions of oxygen, they are more susceptible to the mixture, and, by reason of their being less muscular, they are less prone to inconvenient rigidity and movement. Middle-aged women are almost invariably good subjects. The author has, for example, notes of several cases in which 60-90 seconds' anæsthesia has resulted after an ordinary inhalation of the mixed gases.

Old persons of both sexes are generally very favourably affected by the mixture. The author has anæsthetised, by its means, several patients over 80 years of age. One of these, a gentleman of 88, had an intermittent heart: the administration was conducted until the conjunctiva became insensitive, and an excellent anæsthesia was obtained. The absence of that temporary respiratory embarrassment which is induced by nitrous oxide free from oxygen, and which, in the case of elderly persons with rigid chests, cannot be regarded as free from risk, is a very distinct gain.

General condition.— Other things being equal, the better the patient's state of health the more anæsthetic will he require, and *vice*

versâ. The proportion of oxygen in the mixture, moreover, should be rather smaller in the case of a perfectly healthy subject than in that of a debilitated individual. An exuberance of health and spirits is not always conducive to the most tranquil form of anæsthesia. It may be said, in fact, that patients of a weakly constitution, and those who have recently been suffering from some depressing malady, more often approach our ideal standard of anæsthesia than patients of opposite types.

Physique.—Other things being equal, the more powerfully built the patient the greater will be the quantity of the mixture required. Men of an athletic physique, who have led outdoor lives, and who are in a state of perfect health, often give slight trouble by becoming rigid during the administration and operation. Speaking in general terms, one may say that rather smaller proportions of oxygen should be used in men than in women. Thus it is best, as a rule, to start the administration with the indicator at "1" and very gradually to move it onwards. If oxygen be admitted at the same rate as in anæsthetising women, a long inhalation will be necessary before good anæsthesia is established; and in attaining this anæsthesia excitement will be liable to arise. Men of slim build and rather weakly constitution may be

treated in precisely the same way as women. Very stout subjects, and especially those with thick, short necks, or double chins, tend to become unusually stertorous, so that in such cases it is generally advisable slightly to increase rather than to diminish the usual proportions of oxygen. Very stout elderly women, with feeble heart action, and possibly bronchial symptoms, are remarkably good subjects for nitrous oxide and oxygen administered in this way.

The presence of a beard or moustache.—When hair necessarily intervenes between the cushion of the face-piece and the skin, allowance must be made for the unavoidable ingress of a small proportion of air with the mixture. The best plan in such cases is to secure as accurate a coaptation of the face-piece as possible, and then to surround the air-cushion of the latter with a wet cloth. In this way the author has been able to obtain very good results. In many cases the long inhalation which has resulted from the unavoidable admission of small proportions of air has led to remarkably long anæsthesia. It is impossible, however, in these cases, to be as sure of one's results as in others.

Temperament.—Other factors remaining the same, the best subjects for this as for other anæsthetics, are patients with placid,

equable temperaments. Highly excitable and emotional persons are liable to give slight trouble. They sometimes voluntarily hold the breath, or scream, before the anæsthetic is actually breathed. They often, moreover, require considerable quantities of the mixed gases before the conjunctival reflex vanishes. In many cases, indeed, this reflex will not disappear, and the anæsthetist has to judge by other signs that his patient is ready for the operation. Highly neurotic persons usually display a shorter available anæsthesia than others. Thin, pale, dark-complexioned, young women of nervous temperament, are particularly liable to prove difficult of management. With nitrous oxide alone the full effects of the gas are produced in a few respirations; the asphyxial element is conspicuously present; and the resulting anæsthesia is disturbed and brief. Much better results may be obtained, however, with the mixture if the administration be conducted properly. Oxygen should be rather sparingly admitted at first; it should then be somewhat more freely given, and a long inhalation secured. With regard to hysterical women, we may say that, although one cannot always depend upon obtaining perfect results, such patients are, as a rule, remarkably good subjects for the mixture, provided that oxygen be not too freely ad-

mitted. When such subjects are anæsthetised by nitrous oxide alone, the anæsthesia is so short that during recovery nightmare-dreams and other distressing sensations are likely to arise, and to induce screaming and emotional attacks. The anæsthesia being deeper when the mixture is used, the resulting unconsciousness is quieter and longer, and the recovery is usually unattended by any emotional disturbances. The difference between the two methods of anæsthetising dental patients was very obvious in the administrations conducted by the author at the Royal Dental Hospital. He found that with nitrous oxide and oxygen patients rarely made any sound at all, either during or after the administration ; whereas with nitrous oxide alone phonation was exceedingly common.

Complexion - Colour. — Plethoric, florid patients are more liable than anæmic-looking persons to evince some duskiness during the inhalation. Of all subjects, however, those of a congested, bloated aspect are the most prone to become dusky in appearance. It is not advisable to be guided entirely by the patient's colour in deciding whether more or less oxygen should be given ; for if this course be adopted in the case of patients who quickly and readily show slight duskiness, but who are naturally

excitable, imperfect anæsthesia from too much oxygen may arise. In most cases it is possible to retain the patient's normal colour throughout the administration. Curiously enough, the author has notes of one or two cases in which no very distinct alteration in colour occurred even though, as was obvious from the presence of some degree of clonic spasm, the patient was at the moment breathing a mixture containing very little oxygen. These cases are very exceptional. Should the patient be pale from nervous apprehension, the pallor will become replaced by the natural colour as the inhalation proceeds. Generally speaking, anæmic subjects are very tolerant of oxygen, and in their case this gas should be admitted more freely than usual, the indicator being placed at "3" or "4" at the beginning of the administration.

Alcoholic indulgence. — In anæsthetising alcoholic subjects the administration should be as prolonged as is considered advisable, in order to produce as deep an anæsthesia as possible. As with other anæsthetics, difficulties are liable to arise, and the anæsthetic state is often short and imperfect in character. Movements of the head, arms, or legs are not uncommon during the earlier part of the inhalation, so that care should be taken at this stage not to give more oxygen than is needed to keep asphyxial phenomena

at bay. At the same time it must be remembered that alcoholic patients are singularly intolerant of oxygen starvation, evincing convulsive movements with great readiness. The best line of treatment, apparently, is at first to be somewhat sparing in the oxygen supply, and then, when the excitement stage presumably has passed, to be more liberal with the oxygen, keeping a close watch for any convulsive spasm.

The excessive use of tobacco and other narcotics.—Patients who smoke inordinately are not the best subjects for nitrous oxide, even when given with oxygen. They are inclined to movement, hesitating or suspended breathing, and great muscular rigidity, during the inhalation, and to a short anæsthesia afterwards. All that we can say is that we can obtain by means of the mixture a better result than with nitrous oxide alone. As these patients have a tendency to straighten the whole body at the acme of anæsthesia, the posture in which they are placed for the administration is a matter of importance (see p. 39).

Patients who habitually take **chloral** or **morphine** also become comparatively insusceptible to this as to other anæsthetics. The author has only once met with a temporary maniacal seizure after nitrous oxide and oxygen,

and this was in the case of a young man who, for six consecutive nights, had taken sleeping draughts of chloral and of opium.

The author has notes of several cases in which he has administered nitrous oxide and oxygen to the same patient on several occasions at intervals of from one to ten days. He has almost invariably noticed, under such circumstances, a progressive insusceptibility to the anæsthetic.

Affections of the respiratory system.—Should any marked affection of the respiratory system exist, care must be taken to allow for this, so to speak, in conducting the administration, otherwise asphyxial phenomena, similar to those met with when nitrous oxide is administered in the customary manner, will be liable to arise. If the air-way be partly obstructed by large tonsils, adenoid growths, or other conditions; if the patient be the subject of chronic bronchitis, emphysema, phthisis, or other allied diseases; or if breathlessness from some cardiac affection be present, more oxygen than usual must be given in order to neutralise, as it were, the unusual asphyxial element in the case. If this be done, nitrous oxide anæsthesia may safely be induced in nearly every case.

There are, however, a few highly exceptional conditions in which some other form of anæs-

thesia is preferable. In some patients, dyspnœa may be so acute that no tightly-fitting mask can be tolerated. This may be the case with those suffering from angina Ludovici, aneurysmal or other pressure upon the trachea, very advanced phthisis, hydrothorax, and other grave respiratory conditions. Putting such exceptional cases on one side, we may safely administer nitrous oxide and oxygen to all other patients.

Affections of the circulatory system.—It is now known that patients with diseases of the heart are not unfavourable subjects for anæsthetics, provided that care be taken in selecting appropriate methods. The author has administered nitrous oxide and oxygen to patients with all the commoner forms of morbus cordis. Amongst these have been many cases of aortic regurgitation, advanced mitral and aortic disease, and congenital valvular disease. In all of these cases excellent results have been obtained, and no anxiety has been experienced. Although nitrous oxide, as ordinarily administered, is generally regarded as safe even in advanced heart disease, it is wiser not to adopt the customary plan of administration in such subjects. The case is quite different when nitrous oxide is given with oxygen, for the temporary impairment of respiration, with its consequent temporary general venous engorge-

ment, is prevented, so that no undue strain is thrown upon the right side of the heart. The author has notes of an interesting case which occurred at the Dental Hospital, which is perhaps worth quoting. The patient was a pale, thin, breathless man, who had been an in-patient at Charing Cross Hospital with œdema of the legs and cardiac symptoms following rheumatic fever. He was stated to have double aortic and mitral disease. The heart's action was very tumultuous and irregular. Nitrous oxide, free from oxygen, was administered to him on two occasions by a skilled anæsthetist. On one of these his pupils became enormously dilated, his breathing very difficult, and his conjunctiva insensitive. His appearance was so alarming that no operation was performed. The tongue was drawn forwards, and gradually the threatening symptoms vanished. Nitrous oxide and oxygen were subsequently administered to this patient. The pupils never became widely dilated, and no trouble whatever occurred. In the case of a lad with aortic regurgitation, who was pale, probably from fright, before the administration, the pulse markedly improved and the pallor lessened as the inhalation proceeded: during the operation the normal florid colour was completely restored. The author has observed exactly the

same train of symptoms in a patient, who, at the time of the administration, had an exceedingly feeble pulse, and was pale from shock produced by fruitless attempts to extract a tooth without an anæsthetic. In a patient to whom the mixture was administered—the subject of a large intra-thoracic aneurysm—no bad effects followed. In elderly persons with atheromatous vessels, it is better to administer nitrous oxide and oxygen than nitrous oxide alone.

Dr. Leonard Hill finds that blood pressure under nitrous oxide and oxygen either rises slightly or remains constant; whereas, as Kemp has shown, there is a considerable rise in tension when nitrous oxide is administered in its pure state [13].

Affections of the nervous system.—The author has anæsthetised numerous epileptics, and has not met with any case in which an epileptic attack has arisen during, or immediately after, the inhalation. He has, however, had experience of one case in which a well-marked seizure took place during the administration of pure nitrous oxide; but as the attack came on very early in the administration it would hardly be fair, perhaps, to assume that the absence of oxygen had any influence in its causation.

Pregnancy. — Nitrous oxide and oxygen

may safely be given to patients during the latter months of pregnancy. Although nitrous oxide, free from oxygen is generally regarded as admissible, it would certainly seem wiser to adopt a non-asphyxiating method in these cases. The author has on more than one occasion administered nitrous oxide and oxygen for a dental operation, within a week of the expected confinement, and without any difficulty or subsequent trouble arising. This plan of obtaining anæsthesia, indeed, is of great value in such cases, for on the one hand we are able to avoid the asphyxial accompaniments of an ordinary nitrous oxide inhalation, and, on the other, the possible after-vomiting of ether or chloroform narcosis.

CHAPTER VI.

THE ANÆSTHESIA.

The anæsthesia which is available for a dental operation commences at the moment the face-piece is removed, and should be regarded as terminating at the first indication of returning semi-consciousness. Nothing has contributed more to the unfavourable opinions held by the public concerning "laughing gas" than the practice of continuing the operation whilst the patient is emerging, or has emerged from anæsthesia. With pure nitrous oxide the available unconsciousness is comparatively short, and the transitional lines between deep anæsthesia, semi-anæsthesia and normal consciousness are so narrow that errors of judgment as to whether or not the patient is capable of feeling pain at a given moment are to a certain extent excusable. But with nitrous oxide and oxygen the available anæsthesia is distinctly longer, and the transitional lines are distinctly broader, so that operations which do not admit of being perfectly painlessly performed under nitrous oxide as customarily administered, may be conducted with an absolute

freedom from pain and discomfort under nitrous oxide and oxygen.

Immediately the anæsthetist has removed the face-piece he should direct his attention to **supporting the patient's lower jaw,** or **steadying the head,** according to the nature of the operation. He should at the same time keep a sharp look-out for teeth or fragments of teeth falling or shooting backwards towards the fauces.

It is customary for lower teeth to be removed before upper. If both sides of the mouth are to be operated upon, and if the order of events be a matter of indifference to the surgeon and to his patient, it is better that the left side should first be dealt with, for it is easier to introduce the Mason's gag, should one be required, from this, *i.e.*, the side upon which the anæsthetist stands, than from the other.

The **duration of the available anæsthesia** varies somewhat in different cases. The average duration is about 44 seconds. Other factors remaining the same, the longer the inhalation the longer will be the resulting anæsthesia. On many occasions, for example, the author has continuously administered the mixed gases for three minutes, and has thus been able to secure an available anæsthesia of 50, 60, or even 70 seconds. But although the duration

of the inhalation has a marked influence in determining the length of the subsequent unconsciousness, there are numerous other factors. The type of subject occupies a prominent position amongst these. Children, excitable and neurotic patients, alcoholics, and inveterate smokers, generally remain a shorter time than usual under the influence of the anæsthetic. On the other hand, anæmic, non-excitable young men and young women, middle-aged women of spare build, and persons of both sexes who are in indifferent health, may remain tranquilly anæsthetised for a comparatively long time. The amplitude and rate of the breathing immediately after the face-piece has been removed is another factor. Should the operation be such that the lower jaw is driven down upon the sternum, temporarily obstructed respiration may ensue, and this, by preventing the exit of the imprisoned anæsthetic and the entrance of atmospheric air, will lead to a prolongation of the anæsthesia. The same result may be brought about by sudden alterations in the posture of the head, by which respiration becomes mechanically obstructed. A somewhat similar lengthening of the usual anæsthesia is occasionally observed in stout, wheezy subjects, and in those with chronic bronchitis and emphysema; imperfect expan-

sion of the bases of the lungs in these subjects being favourable to the retention of the anæsthetic gas for a longer time than usual.

Generally speaking, the patient remains perfectly quiet and passive during the operation, provided that a proper limit be placed upon the latter. At the first application of the forceps or elevator there is, however, in many cases a very slight and not inconvenient **reflex movement** of the body. In exceptional cases the movement is greater.

Should the colour have been slightly dusky or paler than the normal when the face-piece was removed, it will quickly become natural when air is admitted. But if the operator depress the lower jaw, or in any other way drive the tongue backwards, and thus temporarily arrest the breathing, some duskiness will necessarily be produced.

Phonation at the beginning of the operation is rarely evoked. Should the patient have been making phonated sounds during the inhalation they may increase somewhat during the operation; but it is not uncommon for the exact reverse of this to take place, and for such sounds suddenly to be arrested when the tooth is grasped by the forceps. The available anæsthesia is far quieter and of a better type than when nitrous oxide has been given free from oxygen. In exceptional

cases, and more particularly in children and very nervous subjects, reflex phonation may occur, but as is well-known, such phonation does not necessarily indicate the perception of pain or, indeed, any knowledge of the operation being performed. It is, moreover, usually not remembered. Reflex phonation is probably more likely to occur when the breathing has been nasal than when it has been oral in character.

There are, unfortunately, no systematic rules by which we can invariably tell when the available **anæsthesia has come to an end.** An endeavour should be made so to adjust the administration and the operation that after the latter has been completed there shall still remain a slight reserve of anæsthesia. In the event, however, of unexpected difficulties arising in the operation, the anæsthetist is rightly expected to give the signal for discontinuing the extraction. It is by no means always an easy matter to say whether, at a particular juncture, the operation should be terminated or continued. Nothing but practical experience is of any avail in deciding points of this kind. The general aspect of the patient, the state of the eyes and pupils, the character of any sounds that may be uttered, and the nature of any movements that may take place—these and other indications

have to be taken into careful consideration. The most successful cases are those in which the operation is performed at the acme of anæsthesia, so that not only is there an absence of all pain, but the patient experiences none of those unpleasant sensations which are likely to arise when an operation takes place during semi-consciousness.

A **re-application** of the face-piece before consciousness has been regained is not to be recommended, except under certain circumstances, for such a procedure is liable to be followed by inconvenient if not objectionable asphyxial effects. If, however, the patient's head be nearly vertical, if the attempt to remove a tooth or teeth has led to little or no hæmorrhage, and if the face-piece be applied before inconvenient recovery-movement has taken place, there is but slight objection to the re-application. When re-applying the anæsthetic the indicator should be brought back to "1" or "2", as in primary administrations, and then moved on somewhat quickly to the higher numbers on the scale, special attention being paid to the character of the respiration during the re-inhalation. Clonic muscular spasm, stertor, and other asphyxial phenomena tend to come on very rapidly during the re-application of nitrous oxide, even though oxygen be present. It is often better, when an extrac-

tion has proved exceptionally difficult, to advise a suspension of the operation, to allow the patient to recover consciousness, to request him thoroughly to wash out his mouth with water, possibly containing a small quantity of sulphate of zinc or some other astringent, and to administer the mixture a second time. The circumstances will in this way be more favourable than if a hurried attempt to extract a difficult tooth be made during imperfect anæsthesia. Re-administrations of the mixture during partial or complete anæsthesia, as well as those conducted after an interval of several minutes' consciousness, are liable to induce nausea and vomiting, so that, whenever possible, they should be avoided. When, in the case of a difficult or protracted dental operation one or more re-applications of the anæsthetic are contemplated, the patient should be dieted as carefully as if ether or chloroform were about to be administered.

In concluding this chapter it may be mentioned that there is no better anæsthetic than that under consideration for **drilling into pulp cavities or for simply opening up the antrum.** The absence of all jactitation and irregular breathing renders such operations far easier of performance than when nitrous oxide is used free from oxygen.

CHAPTER VII.

EXCEPTIONAL CASES.

ALTHOUGH the method of producing anæsthesia which has been described is the safest of all methods at present known to us, it is undoubtedly somewhat complicated. From this it follows that partial or complete failure to bring about typical non-asphyxial nitrous oxide anæsthesia will be liable to occur to everyone who has not had much experience of the method. As more and more experience is gained it will be found that difficulties and exceptional cases are less and less frequently met with, and that eventually such a state of proficiency will be gained that cases displaying any unusual departure from the normal type will be very rare.

Abnormal Susceptibility—Idiosyncrasy.—All degrees of susceptibility to nitrous oxide may be met with. When administering the mixed gases as already described the anæsthetist should observe, particularly in the case of weakly patients, whether the nitrous oxide produces an unusually rapid effect, in other words, whether the conjunctival reflex dis-

appears and the upper lid relaxes sooner than usual. Should such susceptibility be detected, a comparatively short administration is indicated—unless, of course, a lengthy operation is contemplated. If the administration be permitted to occupy the ordinary time recovery will not take place as satisfactorily as usual. Some patients, and particularly those who are exceedingly anæmic and those who are the subjects of pulmonary phthisis, may be extraordinarily susceptible to nitrous oxide even when administered as described. The author has notes of one or two cases in which an asphyxial type of breathing, rapidly followed by separation of the eyelids and wide dilatation of the pupils, has occurred quite early in the administration. In such cases a correspondingly rapid recovery is generally observed. The line of treatment to be adopted with these highly susceptible subjects is to admit oxygen in larger proportions than usual.

Insusceptibility.—Although minor degrees of this condition are not uncommon, marked insusceptibility to nitrous oxide is exceedingly rare. If the administration be conducted with scrupulous attention to all the points to which reference has been made, we shall probably not meet with more than one patient in five hundred displaying such a degree of insus-

ceptibility as to necessitate a definite modification of the usual method. Whilst the peculiarity is most likely to manifest itself in confirmed alcoholic subjects, excessive smokers, and those who have become habituated to other narcotics, cases undoubtedly may occur in which no such causation can be discovered. Thus, the author has met with patients in whom the administration of the mixed gases for double the ordinary inhalation period has produced nothing but an analgesic state in which the perception of sound and the recollection of certain incidents—for example, the removal of teeth in a certain order—have been preserved. In such cases patients may respond to directions given them, even though the conjunctival reflex be at the moment in abeyance. In the most marked cases of insusceptibility it must be confessed that nitrous oxide, at all events in the presence of sufficient oxygen to eliminate all obvious asphyxial phenomena, is incapable of producing even an analgesic state. In cases of this class a prolonged administration of the mixed gases is indicated, with such a diminution in the ordinary quantity of oxygen as will destroy consciousness. In the most extreme cases nitrous oxide, however administered, may be found to be quite useless and some other anæsthetic must be chosen.

Laughter, singing, and articulate shouting. Inarticulate phonation.—The occurrence of such symptoms during the administration usually indicates either that air is gaining admission with the mixture, or that the oxygen proportion is too high.

Muscular phenomena during inhalation.—These may comprise :—

(1) Strictly voluntary movements at the outset of the administration, as for example, putting up the hands with the object of removing the face-piece, &c. Some patients imagine that by moving their fingers, hands, or feet at the beginning of the administration, they are affording valuable assistance to the anæsthetist by providing him with a reliable sign that consciousness is still present. Unfortunately, movements originally voluntary may not only tend to become automatic as consciousness becomes lost, but may even increase to such a degree that the patient's whole body shares in the movement. The author has notes of a case in which the patient, immediately the face-piece was applied, commenced moving her hands synchronously with her respiration. She did not restrain the movements when asked to do so. Gradually the arms, which had been immobile, joined in the rhythmic movements. Eventually when the conjunctiva had become insensitive and the

face-piece was being removed, the movements had acquired such wide excursion that the hands reached the face. The synchronism between the movements and the respiration persisted throughout.

(2) Uncontrollable nervous movements, also at the outset of the administration, *e.g.*, tremor of the legs, or fidgety movements of arms, hands, and fingers.

(3) Intoxication-movements, such as movement of the head from side to side, stamping, alternate thrusting out of the arms, &c. Such movements as these are often associated with laughter or shouting, and like the latter are usually due to air or too large a percentage of oxygen in the mixture. The author has notes, however, of four highly exceptional cases in which the inconvenient phenomena which occurred were, to the best of his knowledge, in no way dependent upon dilution of the nitrous oxide with air or oxygen. On a certain occasion he administered nitrous oxide and oxygen to a young lady about 20. The operator was a very well-known dentist. After four or five breaths of the mixture, the patient began to move so inconveniently that it was impossible to continue the administration. A second inhalation was attempted. Precisely the same phenomena appeared; but, by obtaining assistance, anæsthesia was

eventually induced. Two teeth were painlessly removed. There was nothing abnormal in the patient's appearance, nor did she seem to be hysterical. She gave a history of having had "gas" given to her by a dentist, who broke the tooth, and said he had never before seen a case similar to her own. The patient implicitly obeyed instructions as to breathing, posture, &c. Several months later, at the same dentist's, the author administered nitrous oxide and oxygen to a young man, about 5 ft. 8½ in. in height, who had been a football player. Inconvenient movements of the head came on early in the administration; these extended to other parts of the body; and it was with the greatest difficulty that the operation was performed. The phenomena were very similar to those observed in the other case. As a matter of fact the patients were brother and sister. Curiously enough, two almost identical cases occurred at another dentist's. The patients were, as before, brother and sister, but of middle age. The lady was about 58, unmarried, rather stout and short, and under treatment for pernicious anæmia, possibly dependent upon carious teeth. Nitrous oxide and oxygen were administered as usual. The patient did not fill her chest freely. After five or six imperfect breaths movements com-

menced, simulating those of an epileptic attack. An attempt was made to stop them by requesting the patient to control them, but they increased. Apparently they first affected the head, which jerked almost rhythmically: then the arms and legs and body were affected. It was impossible to keep the face-piece accurately applied; so it was removed with the hope of getting the patient to control herself. The eyelids were separated; the eyes turned upwards; the colour of the features was but little altered. The patient stated that she had heard the request to control herself, but that she had been unable to comply with it. After a few minutes an attempt was again made to anæsthetise her. This time she breathed more freely. The same effects, however, were produced, and in about thirty-five seconds the face-piece had to be removed owing to what appeared to be a general convulsive seizure. Although there was no indication of pain during the removal of the first tooth, there was considerable movement when the second tooth was attempted (the extraction of the first tooth having occupied only about a couple of seconds), and the patient persisted that she had felt pain. The brother of this patient, a middle-aged man, rather thick-set, and of nervous temperament, displayed almost precisely similar symptoms to those

of his sister. It was found to be impossible, indeed, to anæsthetise him with nitrous oxide; and ether had to be employed. There was no history of excess, either as regards alcohol or tobacco, although the former was suspected. As regards the causation and significance of the phenomena in these four cases the author must confess to being completely ignorant. It is quite conceivable that, in the case of the middle-aged lady, the anæmic state from which she was suffering rendered her particularly sensitive to the effects of nitrous oxide. Since anæsthetising her the author has met with another case of pernicious anæmia, in which, during the third inspiration of pure nitrous oxide, convulsive (anoxæmic) phenomena appeared.

(4) Tonic spasm. Some degree of tonic spasm is not uncommon, especially in men, but extreme conditions, such as those to which the terms opisthotonos and emprosthotonos have been applied, are very rare. Sometimes the tonic spasm affects the neck muscles, and the head gradually becomes turned to one or other side. It is difficult to say what these movements depend upon. In many cases they occur when the percentage of oxygen is rather less than usual, but this is not always so. Indeed, if the patient be a vigorous, athletic man, and too much oxygen be admitted with the nitrous

oxide, excitement will arise, and marked rigidity may present itself. It is on such occasions as these that some degree of respiratory spasm, from contraction of thoracic and abdominal muscles, is liable to occur. In this way a primary excess of oxygen may lead to secondary cyanosis, or even to jactitation.

(5) Clonic spasm. Epileptiform twitchings always indicate a diminution in the normal oxygen supply. When the diminution is but slight the clonus may be so mild that it may escape detection. Marked clonic spasm (jactitation) may be met with in extremely anæmic subjects, if the oxygen percentage be below that which is requisite in such subjects. The epileptiform movements may affect all parts of the body. Whenever the anæsthetist detects any such movements commencing during the use of nitrous oxide and oxygen he should at once increase the oxygen supply and the movements will quickly vanish.

(6) Fine tremor of arms and legs occurring during unconsciousness. This is rare; the author has only seen it in three or four cases, and it came on when anæsthesia was fairly well established.

(7) Certain peculiar tonic movements of deep anæsthesia. These are interesting. After a long inhalation of the gases, and when anæsthesia is well established, as may be seen

from the state of the eyes, patients sometimes display peculiar movements of the arms, legs, neck and body. The arms and legs may slowly move in certain directions; the head may slowly turn to one side; or the whole body may begin to turn gradually in one direction or another. The movements often suggest a return of consciousness; but this is not the case. When the face-piece is removed a long and perfectly tranquil anæsthesia follows. The tonic movements differ from those referred to in (4), for they come on after relaxation of the muscular system has been produced. For want of a better term the condition may be called "secondary rigidity."

Cyanosis.—This always depends upon want of oxygen. It may either be brought about by the nitrous oxide bag becoming distended, so that little or no oxygen passes from the oxygen bag, or it may arise from some accidental obstruction between the oxygen bag and the face-piece. It may also take place from respiratory spasm incidental to laughter, crying, or coughing; or it may be occasioned by so-called "holding the breath" during or immediately after the inhalation of the gases. This "holding the breath" is a misnomer, for the patient is not conscious at the time. Certain patients, especially men who are alcoholics, or inveterate smokers, are prone to muscular

spasm, and when this spasm affects the chest and abdomen, temporarily arrested breathing necessarily occurs and may possibly lead to cyanosis. Cyanosis may also arise in connection with the presence of morbid states, such as enlarged tonsils, nasal polypi, post-nasal adenoid growths, bronchitis, &c. And, lastly, a faulty posture of the patient may induce it (see remarks, p. 39).

The following interesting case clearly shows how cyanosis may arise even in the presence of liberal proportions of oxygen if, as may happen in certain subjects, respiration becomes obstructed during the administration. The patient was a highly nervous, thick-set man, aged about 50, with a prominent nose, a florid, glazed face, and a receding lower jaw, a type of subject liable to give trouble to the anæsthetist, no matter what anæsthetic be chosen. The administration was commenced with rather more oxygen than usual. Respiration was at first oral, but it soon became nasal in character. After about 30 seconds the patient began to "hold his breath," probably by reason of partially performed deglutition movements. As only incipient anæsthesia had by this time been produced, an attempt was made, by pushing the lower jaw forwards from behind, to correct the temporary obstruction, but the attempt was unsuccessful. There was, at the moment, some

rigidity and movement of the legs and body. As a result of the obstructed breathing the colour began to become cyanotic. The conjunctival reflex was, however, quite brisk, indicating that no true anæsthesia had yet been secured. An impasse had become established; for whilst more anæsthetic was needed, it was impossible to introduce it. There was only one course open, namely, to remove the face-piece, to stimulate the fauces with the finger in order to remove the obstruction and so secure blood æration, and to re-apply the mixed gases. This course was accordingly adopted. It was found that the tongue and soft palate were in close contact (as in the early stages of deglutition). The introduction of the finger caused a retching movement and immediate air entry. The face-piece was then reapplied. Similar difficulties, however, again occurred and a similar impasse again became established. After some 10 or 15 seconds the face-piece was again removed, and the fauces irritated with precisely similar results. So much intercurrent asphyxia had, by this time, taken place that an anæsthesia differing in its nature from that of nitrous oxide when administered with oxygen had become developed. It is true, of course, that the anæsthesia which had thus arisen was not entirely referable to obstruction, for a considerable quantity of nitrous oxide had

become absorbed. There was, in fact, a mixed anæsthesia, partly due to obstruction and partly to nitrous oxide. In these circumstances the operation was begun and successfully accomplished, though during its performance it was necessary by means of the finger to keep the tongue and soft palate separated in order that respiration might proceed and the incarcerated nitrous oxide escape. Two stumps were removed without pain, though the patient thought he was, to a certain extent, conscious of the removal of the second stump. There was some breathlessness and agitation afterwards and the pulse was somewhat small and quick. There can be no doubt, in fact, that the heart had been subjected to no small strain, and we have yet to learn whether, in such cases, any subsequent ill-effects are likely to be experienced. The case was a difficult one and presented so many points of interest as to be worthy, in the author's opinion, of detailed description.

Shallow, imperceptible, or arrested breathing, associated with a good pulse and colour. This condition, which should not alarm the anæsthetist, is discussed on p. 53.

Very violent respiration at the outset of the administration may generally be corrected by requesting the patient to breathe more quietly. Should consciousness have been lost

when this kind of respiration occurs, an attempt may be made to check it by administering rather less oxygen. Generally, however, the condition subsides spontaneously, to be followed by "respiratory calm" (see p. 53). In some instances, and especially when patients are very nervous, the whole body may move backwards and forwards synchronously with the exaggerated breathing.

Coughing : crying.—Each of these is liable to be followed by asphyxial manifestations, even if the mixture contain a considerable percentage of oxygen. The former may be dependent upon faulty posture, and is to be treated by tilting the head forwards.

Retching or vomiting during the administration.—Retching at the very outset of the administration is to be treated as described on p. 42. Should retching occur towards the end of an administration, the inhalation should be discontinued. Retching movements are most likely to come on in protracted administrations, and when a considerable percentage of oxygen has been used. They are not necessarily followed by vomiting, even though food be present in the stomach. When the patient has abstained from food for several hours, both retching and vomiting are very exceptional.

Epistaxis during anæsthesia is very rare, but it may occur in patients liable to this condition.

The author has met with it on one occasion. The patient was a young lady of 16. Anæsthesia was required for the removal of two upper bicuspid teeth—one on each side—and nitrous oxide and oxygen were administered in the ordinary way. To suit the convenience of the operator the head was adjusted in the slightly thrown-back position. Towards the end of the administration, the respiration, which had been regular, suddenly became suspended, but as temporary suspension of breathing is not uncommon under nitrous oxide, the symptom was not at first taken to indicate anything unusual. The face-piece was removed, and the operation performed, but respiration did not recommence as in ordinary cases. The head and body were tilted forwards, but without beneficial result. Directly the finger was passed to the back of the throat, however, a considerable quantity of blood escaped from the mouth and breathing started. It may be assumed, in this case, that the blood set free in the nasal cavities during anæsthesia found its way to the pharynx, where it produced a half-performed act of deglutition, which thus protected the larynx against invasion. The irritation of the fauces by the finger led to a completion of the act of deglutition, and thus to the entry of air into the larynx. The case clearly indicates the need

for the most careful observation of the respiration. It would also seem to show that a highly dangerous state of affairs might readily come about were suspended breathing from epistaxis to escape attention.

Micturition.—The author has met with this condition only two or three times in twenty years.

Pallor and Pulse Feebleness.—As already mentioned (p. 64), these phenomena generally pass off under nitrous oxide and oxygen. In the following interesting case, however, they did not do so, and it is in the highest degree probable that the somewhat disconcerting condition of the patient was due to the presence of undigested milk within the stomach. The patient was a young man 21 or 22 years of age, who had been working hard in some engineering works where the ventilation was defective and the food indifferent. He had been having attacks of dyspepsia and faintness. The heart sounds were normal. At 8.15 or 8.30 a.m. he had had some milk. At the time of the administration (11.25 a.m.) he was pale and nervous, with small pulse and cold hands. There were restless movements as he sat in the dentist's chair. During the insertion of the mouth-prop the pallor increased, and during the administration the pulse was observed to be small and slow. The breathing was quiet.

After an ordinary inhalation of about 110 seconds the conjunctival reflex was still present. There was no excitement or movement. The resulting anæsthesia lasted about 50 seconds. Two teeth were removed—one of them proving difficult. The colour and pulse did not improve. The chair was tilted backwards, but with no beneficial result, so the patient was carried to a couch. The feeble circulation still persisted. There was neither nausea nor attempted vomiting. Some sal volatile was administered. Ten minutes after the extraction the pulse and colour had improved. Two teaspoonfuls of brandy in water were then given. Although the hands remained rather cold the pulse and colour continued to improve. The patient now experienced a feeling of nausea, but he did not actually vomit. Reference has already been made (p. 37) to the disadvantages of allowing patients to take milk prior to anæsthetisation.

Dangerous Symptoms. — When sufficient oxygen is administered with nitrous oxide to prevent asphyxial complications, the anæsthesia thus produced may be regarded as practically free from risk to life. A careful study of every fatality which has been recorded in connection with the use of nitrous oxide gas shows that in most, and probably in all cases in which this agent has caused death, absence of oxygen has

been primarily responsible for the occurrence. A similar explanation is doubtless applicable to those reported cases in which alarming symptoms have taken place during the administration of nitrous oxide by the customary method. The addition of oxygen to nitrous oxide renders this agent respirable, and robs it of its chief, if not its only, risk. So far as the author is aware, no fatality under nitrous oxide and oxygen has yet been recorded. Although he has now used nitrous oxide with oxygen in several thousands of cases, he has only met with four or five which have given him any anxiety. Two of these have already been mentioned (pp. 88 and 92). In two other cases the patients were powerfully-built, thick-necked men, and breathing became temporarily obstructed by the tongue being spasmodically drawn towards the pharyngeal wall. It was only necessary to separate these structures by means of the finger in order to re-establish breathing. The fifth case was a very remarkable one and is worthy of special notice. The patient was a gentleman about 50 years of age —a retired naval officer. He was rather thin and not noticeably nervous. He had had his tongue completely removed by an eminent surgeon about a month previously. Difficulty in swallowing had persisted since the operation. There was a good deal of mucus, saliva and

muco-pus in the mouth. Anæsthesia, which was required for the removal of three or four roots of teeth, was induced by nitrous oxide and oxygen as described in preceding pages. The patient breathed freely. In about 30 or 40 seconds from the commencement of inhalation a curious, slight, inspiratory stridor was heard. After this had lasted for about 10 seconds, respiration suddenly ceased. It was thought that the breath was being "held," and that respiration would recommence, as it generally does after a few seconds. As breathing did not recommence the face-piece was removed and the operation begun. There had been absolutely no asphyxial accompaniments up to this point, such as stertor, clonic spasm or cyanosis, and the eyes were closed. The commencement of the operation was unattended by any reflex response, either as regards respiration or muscular movement. One or two roots were rapidly extracted from the left side, the Mason's gag was inserted upon that side, and a remaining root was removed from the right side. There was, however, no resumption of respiration during the few seconds occupied by the extraction. A finger was passed into the fauces and down to the laryngeal opening but without any result. Pressure was made upon the chest wall but with very little effect. The patient was now assuming

an asphyxiated appearance. He was placed upon the floor in the lateral posture, in order to allow of the escape of fluid from the larynx, and the chest was rhythmically squeezed. There was an immediate but slight improvement. The eyes were widely open, pupils dilated, and the colour cyanotic. Chest pressure was continued, but very little air entered or left the chest. The fauces were sponged out and tracheotomy instruments rapidly got ready. Fortunately, the patient now began to breathe. Respiration had probably been in abeyance for about two minutes. Directly blood æration had recommenced the patient was moved back to the operating chair. He rapidly regained consciousness, and was quite unaware that anything unusual had occurred. He seemed none the worse for the asphyxial strain to which he had been subjected. There were probably three elements in the causation of the obstructed breathing. These were: (1) the unprotected state of the laryngeal opening occasioned by the complete removal of the tongue; (2) a sudden decrease in the sensibility of the larynx consequent upon the narcotic effects of nitrous oxide; and (3) the entry of salivary and muco-purulent fluid into the larynx. Although such a case must be regarded as one of extreme rarity, it may nevertheless be well to consider whether, by

somewhat different management, one might not have averted the dangerous degree of asphyxia which took place, or have treated that condition more suitably. It would probably have been wiser to have anæsthetised the patient in the lateral posture, and thus to have provided for the drainage of the fluid secretions away from the larynx during the administration. Moreover, the unusual but slight laryngeal sound which undoubtedly indicated the entry of fluid into the larynx, might, with advantage, have been accepted as evidence of the advisability of terminating the administration. Lastly, it is probable that the purely prone posture, as in Schäfer's method of performing artificial respiration, would more quickly have restored respiration than the plan which was employed.

CHAPTER VIII.

AFTER-EFFECTS.

A CAREFUL consideration of the circumstances under which after-effects are likely to arise is of special importance; for the one weak point, if such it may be termed, in nitrous oxide and oxygen anæsthesia, is that this anæsthesia is associated with a somewhat greater liability to unpleasant after-effects than that resulting from the administration of nitrous oxide free from oxygen. Provided, however, that the diet of the patient has been properly regulated, and that the inhalation has not been protracted, recovery from the effects of nitrous oxide and oxygen usually takes place without discomfort. The author has notes of several cases, indeed, in which the patient's condition immediately after the operation was more satisfactory than after a similar operation previously performed under nitrous oxide free from oxygen. Thus, he has known a patient experience severe headache after an ordinary administration of pure nitrous oxide, and to suffer from no such discomfort after the inhalation of this gas with oxygen. In another

of the cases of which he has notes the administration of nitrous oxide *per se* had been followed by numbness of the arms and legs, and blueness of the hands, the symptoms persisting for some time. Recovery was, however, perfect after nitrous oxide and oxygen. In another case, that of a healthy looking lad, the boy appeared to be much better after the administration of the gas with oxygen than after an administration which had previously been conducted in the ordinary way. In a fourth case, that of a man 33 years of age, who had on a previous occasion experienced temporary loss of vision after inhaling pure nitrous oxide, no such symptoms were noted after the use of nitrous oxide and oxygen. In a fifth case—that of a lady of 63, who had had nitrous oxide and oxygen on two occasions without any discomfort whatever—considerable distress was experienced during a series of forcible expirations which occurred at the termination of an administration of pure nitrous oxide. The infrequency of distressing dreams when oxygen is used with nitrous oxide is referred to below.

Should the inhalation have been somewhat protracted, recovery will probably not be quite so satisfactory as after nitrous oxide alone. On such occasions as these, the patient may remain **dazed** and **torpid** for a few minutes, or he may complain of **sleepi-**

ness and wish to be left undisturbed. In some cases, **giddiness, headache,** or **feelings of numbness and tingling** in the limbs may be experienced. **Nausea**, with or without actual retching movements, may also be induced by prolonged administrations, and if there be food present in the stomach, or if blood has been swallowed, vomiting may occur.

As already mentioned (p. 36), it is very important, when a rather difficult dental operation has to be performed, and as long an anæsthesia as possible is desired, carefully to regulate the patient's diet. If this be done, inhalations lasting from two to three minutes may generally be conducted without any subsequent nausea occurring.

The author finds, on looking through his note books, that of the cases in which **retching** or **vomiting** occurred after inhalation, there were eleven in which the interval between the taking of food and the administration was recorded. Of the retching cases, one was a female of 43—interval $2\frac{3}{4}$ hours; another was a female of 45—interval 3 hours; the third was a male of 23—interval 3 hours. Of the vomiting cases, one was a female of 35—interval $4\frac{1}{2}$ hours; one was a female of 13—interval $2\frac{1}{4}$ hours; one was a female of 10—interval $2\frac{1}{2}$ hours. The rest of the vomiting cases were males. Four were aged 15—

intervals 2¾ hours, 2¾ hours, 2 hours, and ½ an hour respectively; one was aged 12—interval 3¼ hours. Although these facts are very meagre, they bring into relief two interesting clinical points. One of these is that, of the cases in which vomiting occurred, the average interval after food was 2½ hours. The other is that, of all subjects, boys from 10—16 are most likely to suffer from vomiting after nitrous oxide and oxygen. The conclusion to be drawn from these observations is that, if we wish to avoid unpleasant after-effects, a long interval after food must be enforced, particularly in the case of young male subjects.

Transient **feelings of faintness, pallor, and feebleness of pulse** are very rare, and are in most, if not in all cases, associated with nausea or impending vomiting.

A word may be said as to the **treatment** of nausea, retching, and vomiting. Slight nausea generally subsides spontaneously after a few minutes. The patient should not be permitted to lie back in the chair, otherwise the swallowing of blood and saliva may favour vomiting. He should bend well forwards, with his head as low as possible, and with his eyes closed. This will generally take away all feelings of nausea. In persistent cases, however, half a tumbler of water, so hot that the finger can hardly be immersed in it, should

be given to the patient to drink. The relief afforded by this simple measure is often remarkable. If retching movements should be present, they will usually quickly subside after this treatment. Even if vomiting has taken place, a draught of very hot water may be given with advantage. Should pallor and faintness attend these gastric disturbances, the patient should be placed horizontally, preferably in the right lateral posture.

Hysterical outbursts, crying, laughing, and similar emotional disturbances are less common than after nitrous oxide free from oxygen. The one case in which the author met with a **temporary maniacal seizure** is referred to on p. 65. He has also once met with curious rigidity of a **cataleptic** character after the administration. The patient was a female aged 26. She displayed the typical phenomena of nitrous oxide and oxygen anæsthesia; but after the operation was over she sat for a few minutes with outstretched hands, open mouth, and closed eyes. Her colour was unaltered.

Distressing dreams are less common after nitrous oxide and oxygen than after nitrous oxide alone. The cause of this difference is difficult to define, but it is probably connected with the deeper form of anæsthesia which undoubtedly follows the inhalation of the

mixture. Generally speaking, either no dream whatever is experienced, or the dream is of a pleasant description. It cannot be denied, however, that in certain subjects, the extraction of a tooth even under the most perfectly established nitrous oxide and oxygen anæsthesia may be associated with such a horrible dream that the patient may prefer, on a subsequent occasion, to undergo the operation without an anæsthetic. Such nightmares, however, are exceedingly uncommon. They are most likely to occur in nervous and highly impressionable subjects.

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M. E. Jenkins M.D.	
C.O.R. Dr. Rethodist	
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